RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS

1967

METRIC EDITION

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REGISTER BOOKS AND OTHER PUBLICATIONS ISSUED BY THE COMMITTEE OF LLOYD'S REGISTER OF SHIPPING

LLOYD'S REGISTER BOOK (The Register of Ships and List of Shipowners are issued annually in July; the Appendix in January).

The Register of Ships (in two volumes A–L and M–Z) contains the names, classes and general information concerning the ships classed by Lloyd's Register of Shipping (including the British Corporation Register); also particulars of all known ocean-going merchant ships in the world, of 100 tons gross and upwards.

The second volume (M–Z) also contains flexible towable containers, ships carrying refrigerated cargo, refrigerated cargo containers, and refrigerated stores classed with Lloyd's Register, as well as lists of changes of ships' names and compound names.

The Register is kept up to date by means of cumulative monthly Supplements containing the latest survey records for all classed ships, and changes of name, ownership, flag, tonnage, &c., for all ships, whether classed or not. Each Supplement is accompanied by particulars of new entries to the Register—that is, new ships and ships of which the names have been changed.

A Weekly List of Alterations in the Register of Ships is also published.

List of Shipowners contains a list of owners and managers of the ships recorded in the Register with their fleets.

The Appendix contains lists of shipbuilders with existing ships they have built; marine enginebuilders and boilermakers; dry and wet docks; telegraphic addresses and codes used by shipping firms; marine insurance companies.

Statistical Tables are issued gratis to Subscribers to the Register Book.

REGISTER OF YACHTS

Published annually in April, this volume contains in addition to detailed information relating to yachts classed by the Society, the names, dimensions, etc., of other British and overseas yachts, whose particulars are known; a list of one-design classes, and the sail numbers of certain classes of racing yachts; also, in an Appendix, particulars of Yacht and sailing Clubs, with the names of Officers; yachts whose names have been changed; yacht builders and designers with the yachts they have built and designed, and a list of Yacht Owners with their addresses, clubs and the names of their yachts.

The Sail Numbers section may be purchased separately.

Illustrations of Club ensigns and burgees, and private flags of yachtsmen. Published separately.

YACHT RULES

Vol. I:—WOOD AND COMPOSITE YACHTS (Sailing, Auxiliary, and Full Power)

Vol. II:—STEEL YACHTS

Vol. III:—INTERNATIONAL RATING CLASSES

PROVISIONAL RULES FOR THE CONSTRUCTION OF REINFORCED PLASTIC YACHTS

A GUIDE TO MACHINERY AND ELECTRICAL EQUIPMENT IN YACHTS

REGISTER OF AMERICAN YACHTS

This Register is published annually in May from the Society's New York Office. Copies may also be obtained on application to the Manager, Lloyd's Register Printing House, Manor Royal, Crawley, Sussex, England.

This book contains the names, dimensions, and full particulars of the yachts of the United States and Canada, so far as they are ascertainable; reproductions in colour of the burgees of yacht clubs and the private signals of yachtsmen; a list of yacht clubs with the names of their officers; an index of signal letters; late names of yachts; and a list of yacht owners of the United States and Canada, with their addresses, clubs and yachts.

Also issued separately:—

Club Burgees and Private Signals (in colour).

RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS, which contain the following:—

Chapter	
	REGULATIONS
A	General Rules and Regulations of Lloyd's Register of Shipping.
B	Classification Regulations.
C	Periodical Survey Regulations.
	CONSTRUCTION RULES
D	Steel Ships.
E	Pumping and Piping.
F	Fire Protection, Detection and Extinction.
G	Conditions for Survey of Machinery during Construction.
H	Main and Auxiliary Engines and Gearing.
J	Boilers and other Pressure Vessels.
K	Spare Gear for Steam and Internal Combustion Machinery Installations.
M	Electrical Equipment and Electric Propelling Machinery.
N	Refrigerated Cargo Installations.
P	Quality and Testing of Materials (including lists of Approved Manufacturers and Proving Establishments).
R	Provisional Rules and Guidance Notes: (A) Methane Gas as fuel for the propulsion of Methane Tankers. (B) Plastic Pipes. (C) Classification of Nuclear Ships. (D) Metal Pipes for Water Services. (E) Torsional Vibration Stresses and Critical Speeds for Main and Auxiliary Oil Engines. (F) Classification of Floating Docks. (G) Propeller—Hull Clearances. (H) Repairs by Welding to Steel Castings for Crankshafts.

A Metric edition of the Rules is also published

EXTRACTS FROM THE RULES:—

	CHAPTER(S)
No. 1	B and C
No. 2	B, C, E, F, G, H, J, K, P and R (A, B, D, E, G and H)
No. 3	E, G, H, K, P and R (A, B, D, E, G and H)
No. 4	J, P and R (A and H) *A Metric edition is also published*
No. 5	F
No. 6	M *A Metric edition is also published*
No. 7	N (and Frozen Meat Stores)
No. 8	P and R (H)

RULES FOR STEEL TRAWLERS

GEOMETRIC PROPERTIES OF ROLLED SECTIONS AND BUILT GIRDERS

Volume I British and U.S.A. Sections Volume II Metric Sections Volume III Japanese Sections

A series of curves giving section modulus and moment of inertia of a wide range of sections used in shipbuilding, in association with varying thicknesses of plating. The areas of sections (without plating) are also given.

ANCHORS—APPROVED DESIGNS

Comprising lists (1) in alphabetical order of Firms, (2) in alphabetical order of name (if any) of anchors, together with descriptive sketches. Revised and brought up to date, 1945.

PROVISIONAL RULES FOR THE CLASSIFICATION OF NUCLEAR SHIPS

PROVISIONAL REQUIREMENTS FOR THE SURVEY OF PRESSURE COMPONENTS FOR LAND-BASED NUCLEAR INSTALLATIONS

LIST OF APPROVED FUSES

LIST OF TYPE TESTED CIRCUIT-BREAKERS

CODE OF PRACTICE FOR THE CONSTRUCTION AND SURVEY OF SHIPS CARGO HANDLING GEAR

PROVISIONAL RULES FOR THE APPLICATION OF GLASS REINFORCED PLASTICS TO FISHING CRAFT

AUTOMATIC CONTROLS IN SHIPS

TERMS OF SUBSCRIPTION FOR THE REGISTER BOOKS AND PRICES OF OTHER PUBLICATIONS UPON APPLICATION TO THE MANAGER, LLOYD'S REGISTER PRINTING HOUSE, MANOR ROYAL, CRAWLEY, SUSSEX, ENGLAND.

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501†

CHANGES EMBODIED IN PRESENT EDITION OF THE RULES

The following additions and amendments have been adopted by the Committee since the previous (1966) edition of the Rules:—

Chapter B — CLASSIFICATION REGULATIONS

Section 1. Para. 114 has been amended.
Section 8. Paras. 805, 806 and 808 have been amended.
Section 9. A new paragraph (903) has been added.

Chapter C — PERIODICAL SURVEY REGULATIONS

Section 1. Para. 102 has been amended.
A new paragraph (104) has been added.
Section 2. Para. heading (A) has been amended.
Paras. 202, 205, 208, 210, 211 and 212 have been amended.
A new paragraph (214) has been added.
Para. 226 has been amended.
Section 3. Para. 307. The paragraph heading has been amended.
Section 5. Para. 502. Two new items have been added.
Section 9. Para. 901 has been amended.
Section 12. Paras. 1203 and 1206 have been amended.
A new paragraph (1207) has been added.

Chapter D — STEEL SHIPS

General

Section 1. A new paragraph (109) has been added.

Definitions

Section 2. Para. 201 has been amended.

Strengthening for Navigation in Ice

Section 10. This section has been revised.

Masts and Rigging

Section 28. This section has been revised.

Equipment

Section 33. This section has been revised.

Tugs

Section 35. Para. 3511 has been amended.
New paragraphs (3512 and 3513) have been added.

TABLES

Table 51 has been revised.
Table 53 has been revised.
Table 54 has been revised.

OIL TANKERS

General

Section 40. Paras. 4003, 4005, 4006, 4007, 4008, 4009 and 4018 have been amended.

Longitudinal Strength

Section 41. This section has been revised.

Decks

Section 42. Paras. 4201 and 4204 have been amended.

Shell Plating

Section 43. Paras. 4301 and 4302 have been amended.
New paragraphs (4303, 4306 and 4307) have been added.
Paras. 4308 and 4311 have been amended.

Bottom, Side and Deck Transverses

Section 46. Para. 4601 has been amended.
A new paragraph (4604) has been added.
Para. 4605 has been amended.
A new paragraph (4614) has been added.
Para. 4615 has been amended.

Bottom and Deck Girders

Section 48. This section has been revised.

Oiltight and Non-Oiltight Bulkheads

Section 50. Paras. 5006 and 5021 have been amended.

Hatchways

Section 51. Para. 5105 has been amended.

Testing

Section 52. Para. 5202 has been amended.

Structural Arrangements at Fore End

Section 54. This section has been revised.

Structural Arrangements at the After End

Section 55. This section has been revised.

Superstructures and Deckhouses

Section 56. This section has been revised.
Table 60 has been amended.
Table 61. This table has been added.

Longitudinal Strength

Section 66. This section has been revised.

Local Strength

Section 67. Paras. 6702, 6703 and 6704 have been amended.

Chapter E — PUMPING AND PIPING

Plans

Section 1. Para. 101 has been amended.

Oil Fuel and Cargo Oils having a Flash Point above 65,5° C.

Section 3. Paras. 307 and 310 have been amended.

Petroleum and other Liquid Cargoes having a Flash Point below 65,5° C.

Section 11. Para. 1104 has been amended.

Liquefied Gases

Section 12. Para. 1209 has been amended.

Chapter F — FIRE PROTECTION, DETECTION AND EXTINCTION

General

Section 1. A new paragraph (105) has been added.

Fire Extinguishers and Extinguishing Systems

Section 3. Para. 327 has been amended.

Chapter G — CONDITIONS FOR SURVEY OF MACHINERY DURING CONSTRUCTION

Section 1. Para. 103. A footnote has been added.
Para. 111 has been amended.

Chapter H — MAIN AND AUXILIARY ENGINES AND GEARING

Turbines and Propelling Motors

Section 3. Para. 305 has been amended.

Reduction Gearing for Propelling and Auxiliary Machinery

Section 5. This section has been revised.

Oil Engines

Section 6. A new paragraph (604) has been added.
Paras. 605, 606 and 607. The definitions of "d" have been amended.
A new paragraph (613) has been added.
Para. 620. The heading has been amended.
Paras. 621, 624 and 625 have been amended.

General Requirements for Oil Engines and Starting Air Compressors

Section 7. Paras. 702, 707, 708 and 711 have been amended.

Strengthening for Navigation in Ice

Section 8. Paras. 801 and 802 have been amended.
Table 7 has been extended.
Paras. 805 and 807 have been amended.
Table 8 has been extended.

Chapter K — SPARE GEAR FOR STEAM AND INTERNAL COMBUSTION MACHINERY INSTALLATIONS

The explanatory note under the Chapter title has been amended.
The section relating to **Boilers** has been amended.

Chapter M — ELECTRICAL EQUIPMENT AND ELECTRIC PROPELLING MACHINERY

General Requirements

Section 1. A cross-reference has been added to the final item.
Paras. 108(b), 109 and 111 have been amended.

Systems of Supply

Section 2. Para. 203. A cross-reference has been added.

Rotating Machinery

Section 4. Table 4.1 has been revised.
Para. 413 has been amended.

Distribution

Section 5. Para. 506. A new sub-paragraph (e) has been added.
Para. 507 has been amended.

Switchboards, Switchgear and Protective Equipment

Section 6. Para. 619. Sub-paragraph (f) has been amended.

Cables

Section 8. Para. 808. Sub-paragraph (f) has been amended.
Para. 810 has been amended.
Tables 8.2 and 8.5 have been amended.
Paras. 824 and 842 have been amended.

Transformers

Section 9. Para. 906 has been amended.

Special Requirements for Oil Tankers and Ships intended for the Carriage in Bulk of Liquid Cargoes having a Flash Point of 150° F. (65,5° C.) or less

Section 16. Para. 1613 has been amended.

Special Requirements for High Voltage Systems

A new Section 18 has been added.

Spare Gear

Section 21. Para. 2101 has been amended.

Chapter N — REFRIGERATED CARGO INSTALLATIONS

Periodical and other Surveys

Section 8. This section has been revised.

Portable Refrigerated Cargo Containers

Section 9. Paras. 928 to 931 have been revised.

Chapter P — QUALITY AND TESTING OF MATERIALS

Steel for Hull Structures

Section 2. Para. 201. Sub-paragraph (a) has been amended.

Steel Castings

Section 5. Para. 502 has been amended and is now preceded by a sub-heading.
Paras. 504, 508 and 511 have been amended.
New paragraphs (512, 516 and 517) have been added.
Paras. 529 and 534 have been amended.

Ingot Steel Forgings

Section 6. Para. 661 has been amended.

Anchors

Section 11. Paras. 1101 and 1104 have been amended.
A new paragraph (1105) has been added.

Chain Cables and Steering Chains

Section 13. This section has been revised.
Table 3A has been revised.
Tables 3B and 4. The Grade headings have been amended.

Steel Wire Ropes for Standing Rigging, Towlines and Mooring Ropes; Fibre Ropes

Section 14. Para. 1403 has been amended.
Para. 1408. Headings in the second Table have been amended.
Para. 1409. Headings in the Table have been amended.
Para. 1410 has been amended.

Chapter R — PROVISIONAL RULES AND GUIDANCE NOTES

R(E) Guidance Notes on Torsional Vibration Stresses and Critical Speeds for Main and Auxiliary Oil Engines
Paras. 101, 102, 109 and 112 have been amended.

New subjects have been added:—

R(G)—Recommendations for Propeller-Hull Clearances.
R(H)—Provisional Rules for Repairs by Welding to Steel Castings for Crankshafts

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A number of alterations of a minor or editorial nature have also been made.

R. B. NANCARROW,
Secretary.

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Chapter A

GENERAL RULES AND REGULATIONS OF LLOYD'S REGISTER OF SHIPPING

Section 1

THIS Society, founded in 1760 and reconstituted in 1834, was established for the purpose of obtaining for the use of Merchants, Shipowners, and Underwriters, a faithful and accurate Classification of Mercantile Shipping, and for the government of which the following Rules and Regulations have been from time to time adopted.

Section 2

The superintendence of the affairs of the Society to be under the direction of a General Committee composed of Merchants, Shipowners, and Underwriters (twenty-four elected in London, namely, nine by the Committee of Lloyd's, twelve by the Committee of the London General Shipowners' Society, and three by the Committee of the Institute of London Underwriters, and thirty-seven at the principal Outports), and the following, namely:—Shipbuilders and/or Engineers, not exceeding ten, who may be elected by the General Committee; additional Members not exceeding twelve, who may be elected by the General Committee; past Chairmen, Deputy-Chairmen and Treasurers, and Deputy-Chairmen and Chairmen of the Sub-Committees of Classification of the Society, who may be elected by the General Committee, and the following *ex-officio* Members, namely:— The Chairman, or, in his absence, the Deputy-Chairman, of the Corporation of Lloyd's; the Chairman, or, in his absence, the Deputy-Chairman, of the London General Shipowners' Society; the Chairman, or, in his absence, the Deputy-Chairman, of the Institute of London Underwriters, and the Chairman of each National Committee established abroad.

The General Committee is further empowered to elect as Honorary Members of the General Committee such persons of distinction and eminence as the General Committee shall from time to time think fit.

Any Member (except an *ex-officio* Member, or a Member elected by the General Committee) who does not attend meetings of the General Committee for twelve consecutive months, without leave of absence, shall cease to be a Member, and his place shall be filled up in the usual way.

NOTE.—Official intimation to be given in June of each year whether the Chairman or Deputy-Chairman of the Corporation of Lloyd's, the Chairman or Deputy-Chairman of the London General Shipowners' Society, and the Chairman or Deputy-Chairman of the Institute of London Underwriters, are to be the *ex-officio* Members for the ensuing twelve months.

Section 3

The General Committee reserve the right of varying or withdrawing the representation of Outports, and of Shipbuilders and Engineers; also the representation of Shipbuilders, Engineers, Steel Makers, and Forgemasters on the Technical Committee hereinafter mentioned, as well as the mode of election of Members.

Section 4

1. Seven of the Members elected in London, namely, three representatives of Lloyd's, three representatives of the London General Shipowners' Society, and one representative of the Institute of London Underwriters, to retire annually by rotation, but to be eligible for re-election. The vacancies so arising to be filled by the election of three representatives by the Committee of Lloyd's, three representatives by the Committee of the London General Shipowners' Society, and one representative by the Committee of the Institute of London Underwriters.

2. Of the Members elected at the Outports twenty-one to retire at the end of four years, and seven of the Members elected at Liverpool and the nine Members elected at Glasgow to retire annually. The retiring Members are eligible for re-election.

3. All Members elected by the General Committee are to retire at the end of four years, and are to be eligible for re-election.

Section 5

The Committee to appoint Sub-Committees of Classification, to be so regulated that each Member of the General Committee may, in rotation, take his turn of duty thereon throughout the year.

Section 6

The Committee to appoint from their own body a Chairman to hold office for such period as they shall determine and two Deputy-Chairmen who shall be elected annually; one Deputy-Chairman being designated Deputy-Chairman and Treasurer and the other Deputy-Chairman and Chairman of the Sub-Committees of Classification.

Section 7

The Secretary, Clerks, and Servants of the Society, and the Surveyors, to be appointed by and be under the direction of the General Committee.

Section 8

Special meetings to be convened by order of the Chairman, or one of the Deputy-Chairmen, or on the requisition of any three Members.

Section 9

All elections and appointments to be made by ballot, excepting when, in the election of Chairman or one of the Deputy-Chairmen, only one person is nominated for each office.

Section 10

No Member of the Committee to be permitted to be present on the decision of the classification of any ship of which he is the owner, or wherein he is directly, or indirectly, interested.

Section 11

1. The Committee to be empowered to make such By-Laws for their own government and proceedings as they may deem requisite, not being inconsistent with the original Rules and Regulations under which the Society was established; but no new Rule or By-Law to be introduced or any Rule or By-Law altered, without special notice being given for that purpose at the meeting of the Committee next preceding that at which such motion is intended to be made ; such notice to be inserted in the summons convening the meeting.

2. No new Rule, or alteration in any existing Rule materially affecting the classification of ships, to be applied compulsorily to ships of which the plans have been submitted and approved before the expiration of six months after the date when the change has been adopted.

Section 12

A Register Book to be printed annually for the use of Subscribers, containing the names of the ships with other useful information, and the character assigned, where the ships are classed by the Society; also the names, etc., of ships of 100 gross registered tons and upwards which are not classed with the Society.

The terms of subscription to be such annual sum or sums as may from time to time be determined by the General Committee.

Section 13

TECHNICAL COMMITTEE

1. The Technical Committee to be constituted as follows:—

Ex-officio—	Ship-owners	Under-writers	Ship-builders	Engineers	Others	TOTAL
The Chairman of Lloyd's Register	–	1	–	–	–	1
The Deputy-Chairman and Chairman of the Sub-Committees of Classification of Lloyd's Register	1	–	–	–	–	1
The Deputy-Chairman and Treasurer of Lloyd's Register	1	–	–	–	–	1
Nominated by—						
The General Committee of Lloyd's Register ...	5	3	2	2	–	12
The Royal Institution of Naval Architects ...	–	–	1	1	–	2
The North-East Coast Institution of Engineers and Shipbuilders	–	–	1	1	–	2
The Institution of Engineers and Shipbuilders in Scotland	–	–	1	1	–	2
The Shipbuilding Conference	–	–	5	–	–	5
The National Association of Marine Enginebuilders	–	–	–	3	–	3
The Institute of Marine Engineers	–	–	–	2	–	2
The British Internal Combustion Engine Manufacturers' Association	–	–	–	1	–	1
The Society of Consulting Marine Engineers and Ship Surveyors	–	–	–	1	–	1
The Dry Dock Owners' and Repairers' Central Council	–	–	–	–	2	2
The Iron and Steel Institute	–	–	–	–	1	1
The British Iron and Steel Federation	–	–	–	–	1	1
The National Forgemasters Association	–	–	–	–	1	1
The Honourable Company of Master Mariners...	–	–	–	–	1	1
The Institution of Electrical Engineers	–	–	–	–	1	1
The British Electrical and Allied Manufacturers' Association	–	–	–	–	1	1
The Technical Committee	3	–	2	2	–	7
„ „ „ (from other countries abroad)	–	–	–	–	8	8
	10	4	12	14	16	56

The above nominations to be subject to confirmation by the General Committee.

In addition to the foregoing:—

(*a*) National Committees abroad may select representatives to attend meetings of the Technical Committee.

(*b*) Further persons may, with the consent of the General Committee, be co-opted to serve on the Technical Committee.

2. The function of the Technical Committee is to consider any technical problems connected with the Society's business and any proposed alterations in the existing Rules, or to frame new Rules, for the classification, survey and building of ships (hull and machinery).

3. The term of office of all Members to be four years, one-fourth retiring each year, the Members so retiring to be eligible for renomination for a second term. Unless specially so authorised by the General Committee, no Member, other than the Chairman and/or Vice-Chairmen, who has served for two periods

of four years to be eligible for renomination for a third term until after the expiration of at least one year. In the event of any vacancy occurring before the expiration of a term of four years a representative to be nominated to fill the vacancy for the unexpired portion of the term.

4. With the exception of any Superintendents nominated by the Technical Committee, only those who are actually partners in firms, or directors or managers of joint stock companies, or of similar status, to be eligible for membership.

5. The Technical Committee to appoint from their own body, biennially, a Chairman, who must be a Member of the General Committee, and, if desired, two Vice-Chairmen, who need not be Members of the General Committee. The same Members not to be eligible to hold office for more than four years in succession, unless on the occasion of the third election a ballot—to be taken whether there be any other candidates or not—shows a majority in their favour of at least three-fourths of the Members present. The appointment of Chairman and of Vice-Chairmen to be confirmed by the General Committee.

6. Meetings of the Technical Committee to be convened as often and at such times and places as may appear necessary, but there shall be at least three meetings in each year.

7. Members desiring to propose alterations in, or additions to, the Rules for the classification, survey or building of ships (hull and machinery) shall give notice of all such proposals in writing to the Secretary.

Every meeting to be convened by notice from the Secretary, if possible one month before the date of meeting; and the Secretary to send to each Member an agenda paper as soon as possible thereafter.

8. Any proposals of the Technical Committee involving any amendment of, or addition to, the Rules for the classification, survey or building of ships (hull and machinery) to be reported to the General Committee, who will refer them to a special meeting of the General Committee, as required by Section 11 of this Chapter.

9. The Technical Committee to be empowered:—

(i) to draw up, if they so desire, By-Laws for governing procedure at meetings;

(ii) to appoint Panels of the Committee;

(iii) to co-opt to the main Committee, or to such Panels, representatives of any organisation or industry or private individuals for the purpose of considering any particular problem.

10. The General Committee reserve to themselves the right of varying, adding to, or rescinding, at their discretion, any or all the foregoing Regulations in this Section.

Section 14

All reports of survey are to be made by the Surveyors according to the form prescribed, and submitted for the consideration of the General Committee, or of the Sub-Committees of Classification but the character assigned by the latter to be subject to confirmation by the General Committee.

Section 15

The reports of the Surveyors (and all documents and proceedings relating to the classification of ships) are to be carefully preserved and shall, subject to the approval, in his absolute discretion, of the Chairman, or one of the Deputy-Chairmen, be open to the inspection of the Owner and of any other person authorised in writing by the Owner.

Copies of reports will, subject to the approval of one of the Chairmen as indicated above, be supplied to Owners, or their representatives, on application.

Section 16

The Surveyors to the Society are not to be permitted (without the especial sanction of the Committee) to receive any fee, gratuity, or reward whatsoever for their own use or benefit, for any service performed by them in their capacity of Surveyors to this Society, on pain of immediate dismissal.

Section 17

The Committees of the Society use their best endeavours to ensure that the functions of the Society are properly executed, but it is to be understood that neither the Society nor any Member of any of its Committees nor any of its Officers, Servants or Surveyors is under any circumstances whatever to be held responsible or liable for any inaccuracy in any report or certificate issued by the Society or its Surveyors, or in any entry in the Register Book or other publication of the Society, or for any act or omission, default or negligence of any of its Committees or any Member thereof, or of the Surveyors, or other Officers, Servants or Agents of the Society.

Section 18

The funds and accounts to be under the authority and control of the Committee.

Section 19

Fees are chargeable for all surveys held by the Society's Surveyors at ports in the United Kingdom in accordance with established scales.

For all surveys held at ports abroad fees will be chargeable according to the nature and extent of the services rendered.

Travelling expenses incurred by the Surveyors in connection with the above services are also chargeable.

Section 20

The class of a ship is liable to be withheld, or, if already granted, may be withdrawn from the Register Book, in the case of non-payment of any fees or expenses chargeable on account of such ship.

28th January, 1965

Chapter B

CLASSIFICATION REGULATIONS

Section 1

CLASSIFICATION

General

101 Steel ships built in accordance with the Society's Rules and Regulations, or with alternative arrangements equivalent thereto (*see* B 501), will be assigned a class in the Register Book and will continue to be classed so long as they are found, upon examination at the prescribed annual and other periodical surveys, to be maintained in a fit and efficient condition and in accordance with the requirements of the Rules.

The Committee, in addition to requiring compliance with the Society's Rules, may require to be satisfied that very small ships, or ships of special type are suitable for the geographical limits of service contemplated.

Classification will be conditional upon compliance with the Society's requirements in respect of both hull and machinery (i.e., main and auxiliary engines, boilers, essential appliances, pumping arrangements and electrical equipment).

The Rules are framed on the understanding that ships will be properly loaded and handled; they do not, unless stated in the class notation, provide for special distributions or concentrations of loading. The Committee may also require additional strengthening to be fitted in any ship which, in their opinion, may be subjected to severe stresses due to particular features in her design or when it is desired to make provision for exceptional loaded or ballasted conditions. In these cases particulars are to be submitted for consideration.

The Committee cannot assume responsibility for stability, trim, hull vibration or other technical characteristics not covered by the Rules, but they are willing to advise on these matters. They are also willing to act in respect of national and international statutory safety and other requirements for passenger and cargo ships governing arrangements not covered by the Society's Rules.

Character of Classification and Class Notations

102 Class 100A1. This class will be assigned to sea-going ships built in accordance with the Society's Rules and Regulations for the draught required.

103 Class 100A1 oil tanker. This class will be assigned to sea-going tankers intended to carry oil in bulk and built in accordance with the Society's Rules and Regulations for the draught required.

Where the scantlings and arrangements have been approved by the Committee for the carriage of oil having a flash point above 65,5° C., or other liquid cargoes in bulk, the class notation affixed to the character will be suitably modified to show the nature of the cargo.

104 Class 100A1 liquefied gas carrier, type of gas(es) in independent tanks, maximum vapour pressure, minimum temperature and where necessary maximum temperature (to be specified). This class will be assigned to sea-going ships specially designed for the carriage of liquefied petroleum, natural or other gases and built in accordance with the Society's Rules and Regulations for the draught required.

105 Class 100A1 ore carrier. This class will be assigned to sea-going ships specially designed for the carriage of ore and built in accordance with the Society's Rules and Regulations for the draught required.

106 Class 100A1 trawler, 100A1 stern trawler, 100A1 fishing vessel. These classes will be assigned to ships built in accordance with the appropriate Rules and Regulations for the Construction of Steel Trawlers.

107 Class 100A1 tug. This class will be assigned to all sea-going tugs built in accordance with the Society's Rules and Regulations for such ships.

108 Class 100A1 dredger, 100A1 hopper dredger, 100A1 hopper barge. These classes will be assigned to dredgers and hopper barges built in accordance with the Society's Rules and Regulations for such ships.

109 Class 100A1 for restricted service or for special purposes. This class will be assigned to sea-going ships intended to operate within specific limits or for special purposes and built in accordance with the Society's Regulations and the scantlings, arrangements and equipment specially approved by the Committee for such ships. The class notation affixed to the character in the Register Book will indicate the geographical limits of the service or the particular purpose for which the class is assigned.

110 Class A1 for restricted service. This class will be assigned to ships intended to trade only within specially sheltered waters, such as harbours, rivers or estuaries, provided the scantlings, arrangements and equipment are approved by the Committee as suitable for such service. The class notation affixed to the character will indicate the geographical limits for which the ship has been approved.

111 Special cargoes. When the scantlings and arrangements have been approved for cargoes of a special nature an appropriate class notation will be entered in the Register Book.

112 Special features. When a special feature in the design or construction of a ship or its machinery has been approved, an appropriate class notation may be entered in the Register Book.

113 Corrosion control. Where an approved method of corrosion control is fitted and an appropriate reduction in scantlings has been permitted, the notation (cc) will be entered in the Register Book.

114 Strengthening for Navigation in Ice. Where an ice class notation is desired, additional strengthening is to be fitted in accordance with the special requirements given in the Rules which are based on Baltic conditions. Four classes of ice strengthening are detailed in the Rules:—

Ice Class 1* strengthening is for ships intended to navigate in extreme ice conditions.

Ice Class 1 strengthening is for ships intended to navigate in severe ice conditions.

Ice Class 2 strengthening is for ships intended to navigate in intermediate ice conditions.

Ice Class 3 strengthening is for ships intended to navigate in light ice conditions.

It is the responsibility of the Owner to determine which notation is most suitable for his requirements.

Section 2

EQUIPMENT

201 The figure 1 in the character of classification assigned to a ship indicates that her equipment of anchors, chain cables and hawsers is in good and efficient condition and in the cases of ships not classed for a special or restricted service, in accordance with the requirements of the Rules. In the case of ships classed for a special or restricted service, the figure 1 indicates that the equipment has been approved by the Committee as suitable for the particular service.

202 When the equipment of a ship is not supplied or maintained in accordance with the requirements of the Rules but is considered by the Committee to be acceptable for the particular service, the Committee may agree to the figure 1 being omitted and a line inserted after the character, thus, 100A–. In cases where the equipment is found to be seriously deficient in quality or quantity, the class of the ship will be liable to be withheld from the Register Book. Special consideration will be given to ships intended to be classed for which, by reason of their particular purpose or service, normal equipment may be unnecessary. In such cases the figure 1 may be omitted from the character of classification, viz., 100A.

Section 3

MACHINERY

301 The machinery, as defined in B 101, is to be constructed and installed on board ship in accordance with the Society's Rules and Regulations. On satisfactory completion of trials, an appropriate class notation will be assigned in the Register Book, thus, LMC (Lloyd's Machinery Certificate).

Section 4

MATERIALS

401 The materials used in the construction of hulls and machinery intended for classification, or in the repair of ships already classed, are to be of good quality and free from defects and are to be tested under the supervision of the Society's Surveyors in accordance with the requirements of Chapter P. The steel is to be manufactured by an approved process at works recognised by the Committee. Alternatively, tests to the satisfaction of the Committee will be required to demonstrate the suitability of the steel.

Section 5

EQUIVALENT ARRANGEMENTS

501 Alternative arrangements will be permitted, provided they are considered by the Committee to be equivalent to the Society's requirements.

Section 6

NEW CONSTRUCTION

Submission of Plans

601 When it is intended to build a ship for classification with the Society, constructional plans and particulars of the hull, equipment and machinery (*see* B 101), as detailed in the Rules, are to be submitted through the local Surveyors for the approval of the Committee before the work is commenced.

Any subsequent modifications or additions to the scantlings, arrangements or equipment shown on the approved plans are also to be submitted for approval.

Novel Forms of Construction

602 Where the proposed construction of any part of the hull or machinery is novel in design, or involves the use of unusual material, or where experience, in the opinion of the Committee, has not sufficiently justified the principle or mode of application involved, special tests or examinations before and during service may be required. A suitable notation will be inserted in the Register Book when the Committee consider this necessary.

Special Survey during Construction

603 New ships intended for classification are to be built under the Society's Special Survey and when classed will be entitled to the distinguishing mark ✠ inserted before the character in the Register Book thus: ✠100A1.

New machinery for ships classed or intended for classification is to be constructed under the Society's Special Survey, and on completion will be entitled to the distinguishing mark ✠ inserted before the machinery class notation in the Register Book, thus: ✠LMC.

From the commencement of the work until the completion of the ship and final test of the machinery under working conditions, the Surveyors are to examine the materials, workmanship and arrangements. Any items not in accordance with the Rules or the approved plans, or any material, workmanship or arrangement found to be unsatisfactory are to be rectified.

Date of Build

604 The date of completion of the Special Survey during Construction of ships built under the Society's inspection will normally be taken as the date of build to be entered in the Register Book. If the period between launching and completion or commissioning is, for any reason, unduly prolonged, the dates of launching and completion or commissioning may be separately indicated in the Register Book.

When a ship upon completion is not immediately put into commission, but is laid up for a period, the Committee, upon application by the Owner, prior to the ship proceeding to sea, may direct an examination of the ship to be made in dry dock by the Society's Surveyors. If, as the result of such survey, the hull and machinery be reported in all respects free from deterioration, the subsequent Special Survey will date from the time of such examination.

Section 7

CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY

701 The requirements of the Committee for the classification of ships which have not been built under the Society's survey are set forth in C 12.

Section 8

PERIODICAL SURVEYS

Annual Surveys

801 All steel ships are to be surveyed at intervals of approximately one year, in accordance with the requirements set forth in C 1.

Docking Surveys

802 Owners should notify the Society whenever a ship can be examined in dry dock or on a slipway. It is desirable that ships should be examined in dry dock at intervals of about 12 months; the maximum interval is to be two years.

This regulation is not applicable to ships operating in fresh water or to certain non-propelled craft; the interval between drydockings for these ships may be greater than is stated above.

The date of the last examination in dry dock or on a slipway will be recorded in the Supplement to the Register Book.

Special Surveys

803 All steel ships classed with the Society are also to be subjected to Special Surveys in accordance with the requirements set forth in C 2 to C 8. These surveys become due at 4-yearly intervals, the first 4 years from the date of build or date of Special Survey for Classification, and thereafter 4 years from the date of the previous Special Survey.

Period allowed for completion of Special Surveys

804 When it is inconvenient for Owners to fulfil all the requirements of a Special Survey at its due date, the Committee will be prepared to consider its postponement, either wholly or in part, provided that the Society's Surveyors are afforded an opportunity, about the due date, of assessing the general condition of hull and machinery. For this purpose the Committee will normally call for a general examination of the ship, including drydocking, of sufficient extent to be assured that her condition is satisfactory for the period of grace desired, which is not to exceed 12 months from the due date.

Special Surveys which are commenced prior to their due date are not to extend over a period greater than 12 months, except with the prior approval of the Committee, who will be prepared to consider suitable arrangements for carrying out Special Surveys over an extended period in the case of ships engaged on a regular schedule.

Record of Special Surveys

805 Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the date. For Special Surveys at which the prescribed requirements for determining the thickness of the structure have been complied with, the record "TD" (thickness determined) will be entered; if the interval between the determination of the thickness is limited to 4 years then the record will be "TD 4". Where a Special Survey is not completely carried out at one time, the date recorded in the Supplement will be the date at which the principal part of the requirements is complied with. Records of Special Survey will not be assigned until the Society's requirements for machinery surveys detailed in 807 or 808 are satisfactorily completed.

Continuous Surveys

806 When, at the request of Owners, it has been agreed by the Committee that the complete survey of the hull may be carried out on the Continuous Survey basis, all compartments of the hull should be opened for survey and testing in rotation with an interval of five years between consecutive examinations of each part.

If the examination during Continuous Survey reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor.

Ships which have satisfactorily completed the cycle will have a record entered in the Supplement to the Register Book indicating the date of completion.

Surveys of Machinery

807 Machinery, as defined in B 101, is to be submitted to the surveys set forth in C 5 to C 11.

Complete Surveys are to be carried out as part of the Special Survey and, whether or not they are commenced prior to their due date, are not to extend over a period greater than 12 months without approval. On satisfactory completion of the survey an appropriate record will be made in the Supplement to the Register Book. When a Complete Survey of the machinery is not carried out at one time the date recorded in the Supplement will be that on which the major portion of the survey is carried out.

If it is found desirable that any part of the machinery should be again examined before the due date of the next survey, a certificate for a limited period will be granted in accordance with the nature of the case.

Continuous Surveys of Machinery

808 When, at the request of Owners, it has been agreed by the Committee that the complete survey of the machinery may be carried out on the Continuous Survey basis, the various items of machinery should be opened for survey in rotation, so far as practicable, to ensure that the interval between consecutive examinations of each item will not exceed five years. In general, approximately one-fifth of the machinery should be examined each year.

In such cases a record indicating the date of completion of the Continuous Survey cycle will be made in the Supplement to the Register Book.

If any examination during Continuous Survey reveals defects, further parts are to be opened up and examined as considered necessary by the Surveyor and the defects are to be made good to his satisfaction.

Boiler, Steam Pipes and Screw Shaft Surveys

809 Boiler Surveys, examination of Steam Pipes and Screw Shaft Surveys should be carried out as set forth in C 9, C 10 and C 11. On satisfactory completion, appropriate records will be made in the Supplement to the Register Book.

Section 9

REFRIGERATION

901 On application from Owners, refrigerated cargo installations which comply with Chapter N of the Rules and are favourably reported on by the Surveyors will be assigned an appropriate class in accordance with N 1. Certificates will be issued and the class notation, together with the particulars of the installation, will be entered in the Supplement.

902 The class assigned will be retained provided the installation is found to be in a good and efficient condition at the Periodical, Loading Port and other Surveys set forth in N 8.

903 The paragraphs in B 14 regarding Withdrawal of Class and in B 15 regarding Reclassification, apply also to Refrigerated Cargo Installations.

Section 10

REPAIRS AND ALTERATIONS

Repairs

1001 All repairs to hull, equipment and machinery which may be required in order that a ship may retain her class are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyors. When repairs are effected at a port where there is no Surveyor to this Society, the ship is to be surveyed by one of the Society's Surveyors at the earliest opportunity.

1002 When at any survey the Surveyors consider repairs to be necessary, either as a result of damage, or of wear and tear, they will communicate their recommendations at once to the Owners, or their representative, and if compliance therewith cannot be arranged, immediate notification will be given by the Surveyors to the Committee.

Alterations

1003 Plans and particulars of any proposed alterations to the approved scantlings and arrangements of hull, equipment, or machinery are to be submitted for approval and such alterations are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyors.

Section 11

APPEAL FROM SURVEYORS' RECOMMENDATIONS

1101 If the recommendations of the Society's Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to the Committee, who may direct a special examination to be held.

Section 12

NOTICE OF SURVEYS

1201 It is the responsibility of Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Society's Surveyors.

It is, however, the normal practice of the Society to give timely notice to Owners when Special Surveys become due, but the non-receipt of such notice, or of notice regarding other surveys, does not absolve Owners from this responsibility.

Section 13

CERTIFICATES

1301 When the required reports on completion of the Special Surveys of new ships, or of existing ships submitted for classification, have been received from the Surveyors and approved by the Committee, certificates of first entry of classification, signed by the Chairman, Deputy-Chairman and Treasurer, or Deputy-Chairman and Chairman of the Sub-Committees of Classification, and countersigned by the Secretary, will be issued to Builders or Owners.

1302 Certificates of class maintenance in respect of completed periodical surveys of hull and machinery will also be issued to Owners on application.

1303 The Society's Surveyors are permitted to issue provisional certificates to enable a ship, classed with the Society, to proceed on her voyage provided that, in their opinion, she is in a fit and efficient condition. Such certificates will embody the Surveyor's recommendations for continuance of class, but in all cases are subject to confirmation by the Committee.

Section 14

WITHDRAWAL OF CLASS

Owners' Request

1401 When the class of a ship, for which the Regulations as regards surveys on hull, equipment and machinery have been complied with, is withdrawn by the Committee in consequence of a request from the Owners, the notation "Class withdrawn at Owners' request" (with date) will be made in the Supplement and the notation "LR class withdrawn—Owners' request" (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

Non-Compliance with the Regulations

1402 When the Regulations as regards surveys on the hull or equipment or machinery have not been complied with and the ship thereby is not entitled to retain her class, the class will be withdrawn and the notation "Class withdrawn" (with date) will be made in the Supplement and the notation "LR class withdrawn" (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

Reported Defects

1403 When it is found from reported defects in the hull or equipment or machinery that a ship is not entitled to retain her class in the Register Book, and the Owners fail to repair such defects in accordance with the Society's requirements, the class will be withdrawn and the notation "Class withdrawn—Reported defects" (with date) will be made in the Supplement and the notation "LR class withdrawn—Reported defects" (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

Infringement of Freeboard Conditions

1404 Where any ship proceeds to sea with a less freeboard than that approved by the Committee or where the freeboard marks are placed higher on the ship's sides than the position assigned or approved by the Committee, the ship's class will be liable to be withdrawn.

Section 15

RECLASSIFICATION OF SHIPS

1501 When reclassification is desired for a ship for which the class previously assigned has been withdrawn, the Committee will direct a Special Survey for Reclassification, appropriate to the age of the ship and the circumstances of the case, to be carried out by the Society's Surveyors.

If at such survey the ship be found or placed in a good and efficient condition in accordance with the requirements of the Rules and Regulations the Committee will be prepared to reinstate her original class or assign such other class as may be deemed necessary.

The date of reclassification will be recorded in the Supplement to the Register Book.

28th July, 1966

Chapter C

PERIODICAL SURVEY REGULATIONS

Section 1

ANNUAL AND DOCKING SURVEYS

Annual Surveys

101 Annual Surveys as required by B 801 should, whenever practicable, be held concurrently with statutory annual or other load line surveys.

102 The Surveyor is to satisfy himself as to the efficient condition of the following:—

Hatchways on freeboard and superstructure decks, ventilator and air pipe coamings, exposed casings, fiddley openings, skylights, flush deck scuttles, deckhouses and companionways, superstructure bulkheads, side, bow and stern doors, side scuttles and deadlights, ash shoots and other openings, together with all closing appliances.

Means of ensuring watertightness of steel hatch covers,

Scuppers and sanitary discharges (as far as practicable) with valves; guard rails and bulwarks, freeing ports gangways and lifelines, fittings and appliances for timber deck cargoes.

The Surveyor should satisfy himself regarding the freeboard marks on the ship's side.

103 Attention is to be paid to all parts of rod and chain gears. All pins are to be examined and the chain in the vicinity of the blocks is to be cleaned and examined for wear and tear. Any length of chain so worn that its mean diameter at its most worn part is reduced to the size given in Chapter D, Table 55, is to be renewed.

All replacements of chains are to be subjected, under the Society's supervision, to the proof tests as set forth for short-link cables in P 13 and the certificates are to be produced. It is recommended that, in addition, the breaking test as required in P 13 should be applied to these chains, and that the tests be made at a proving establishment recognised by the Committee.

It is recommended that repaired chains be tested by the repairers and a certificate to that effect produced.

It is recommended that a set of spares as required by D 2714 be provided.

The various parts of the auxiliary steering gear are to be assembled and examined in order to ascertain that the gear is in good and workable condition.

104 The Surveyor is to examine internally a forward and an after hold or tank at the second Annual Survey after the fourth and subsequent Special Surveys on a dry cargo ship and the third and subsequent Special Surveys on a tanker.

Docking Surveys

(*See* B 802)

105 When a ship is in dry dock or on a slipway she is to be placed on blocks of sufficient height, and proper staging is to be erected as may be necessary for the examination of the shell plating, sternframe and rudder.

Attention is to be given to parts of the structure particularly liable to excessive corrosion or to deterioration from causes such as chafing and lying on the ground and to any undue unfairness of the plating of the bottom.

General

106 At Annual and Docking Surveys the Surveyor should examine the ship so far as is practicable in order to satisfy himself as to her general condition.

107 When chain cables are ranged the anchors and cables should be examined by the Surveyor.

108 The requirements for the survey of main and auxiliary engines, boilers and electrical equipment are set forth in C 5 to C 11.

Annual and Biennial Surveys of Fire Equipment

109 The arrangements for fire protection, detection and extinction in passenger ships are to be examined annually; in cargo ships the arrangements for fire detection and extinction are to be examined biennially.

Surveys carried out by the National Authorities of the countries in which ships are registered may be accepted as meeting these requirements.

Surveys for Damage or Alterations

110 At any time when a ship is undergoing damage repairs or alterations, any exposed parts of the structure normally difficult of access should be specially examined, e.g., if any part of the main or auxiliary machinery, including boilers, or insulation or fittings is removed for any reason the steel structure in way should be carefully examined by the Surveyor, or when cement in the bottom or covering on decks is removed the plating in way should be examined before the cement or covering is relaid.

Section 2

SPECIAL SURVEYS—HULL REQUIREMENTS

(*For Tankers, see also* C 3.)

(A) At the Special Survey of ships under 5 years old.—The Requirements of an Annual Survey (*see* 102 and 103) are to be complied with, in addition to the following:—

201 The ship is to be placed on blocks of sufficient height in a dry dock, or on a slipway; proper staging is to be erected as necessary and the shell plating, sternframe and rudder are to be examined.

The rudder is to be lifted for examination of pintles if considered necessary by the Surveyor.

202 The holds, 'tween decks, peaks, deep tanks, engine and boiler spaces, coal bunkers and other spaces are to be cleared and cleaned as necessary and examined. The bilges and limbers all fore and aft are to be cleaned and the structure examined. Platform plates in engine and boiler spaces are to be lifted as may be necessary for the examination of the structure below.

Where necessary close and spar ceiling, lining and pipe casings are to be removed for examination of the structure.

203 In ships having a single bottom, a sufficient amount of close ceiling is to be lifted all fore and aft on each side from the bottom and bilges to permit the structure below to be examined.

204 In ships having a double bottom, a sufficient amount of ceiling is to be removed from the bilges and inner bottom to enable the condition of the plating to be ascertained. If it is found that the plating is clean and in good condition, and free from rust, the removal of the remainder of ceiling may be dispensed with. The Surveyor may waive the removal of heavy reinforced compositions if there is no evidence of leakages, cracking or other faults in the composition.

205 The steelwork is to be exposed and cleaned as may be required for its proper examination by the Surveyor. Careful examination is to be made of parts of the structure particularly liable to excessive corrosion or to deterioration from causes such as chafing, lying on the ground, or handling of cargo.

Attention is to be given to the shell plating in way of side, bow and stern doors, ash shoots and other openings.

The Surveyor may require to ascertain by drilling or other approved means, the thickness of the material in any portion of the structure where signs of wastage are evident or wastage is normally found. Any parts of the structure which are found defective or materially reduced in scantlings are to be made good by materials of the approved scantlings and quality. Attention is to be given to the structure in way of discontinuities. Surfaces are to be recoated as necessary.

206 In cases where the inner surface of the bottom plating is covered with cement, asphalt, or other composition, the removal of this covering may be dispensed with, provided it be inspected, tested by beating or chipping, and found sound and adhering satisfactorily to the steel.

207 Double bottom compartments, peak tanks and all other tanks are to be tested by a head sufficient to give the maximum pressure that can be experienced in service.

Tanks may be tested afloat provided their internal examination is also carried out afloat.

Tanks forming parts of the main structure, except as stated below, are to be cleaned and examined internally, special attention being given to tanks under boiler spaces. Tanks (excluding peak tanks) used exclusively for oil fuel or for oil fuel and fresh water ballast need not be examined internally provided, after external examination and testing in accordance with the requirements set out above, the Surveyor finds the condition of these compartments satisfactory.

208 All decks, casings and superstructures are to be examined. Attention is to be given to the corners of openings and other discontinuities in way of strength decks and top sides.

209 Wood decks or sheathing are to be examined ; if decay or rot is found or the wood is excessively worn it should be renewed. When a wood deck, laid on stringers and ties, originally required to be 75 mm. is worn to 65 mm., or 65 mm. to 50 mm., it is to be renewed.

Attention is to be given to the condition of the plating under wood decks, sheathing or other deck covering. If it is found that such coverings are broken or are not adhering closely to the plating, sections should be removed as necessary to ascertain the condition of the plating. (*See also* C 110.)

210 The masts, standing rigging and anchors are to be examined. If the chain cables are ranged they should be examined. (*See* Chapter D, Table 55 for renewals).

The Surveyor should satisfy himself that there are sufficient mooring ropes on board and also that a tow line is provided when this is a rule requirement.

211 The steering gear, and its connections and control systems (main and alternative) are to be examined. The various parts of the auxiliary steering gear are to be assembled and examined.

212 The windlass (*see* C 502), hand pumps, suctions, watertight doors, air and sounding pipes are to be examined. When examining tanks internally the Surveyor should see that striking plates are fitted under sounding pipes.

213 Where holds are insulated for the purpose of carrying refrigerated cargoes, and the hull in way of the insulation was examined by the Society's Surveyors at the time such insulation was fitted, it will be sufficient to remove the limbers and hatches to enable the framing and plating in way to be examined; in other cases additional insulation is to be removed as necessary to satisfy the Surveyor as to the condition of the structure. (*See also* N 8.)

214 The Surveyor is to satisfy himself as to the efficient condition of the following:—

Means of escape from (a) machinery spaces, (b) crew and passenger spaces, (c) spaces in which crew are normally employed.

Means of communication between (a) bridge and engine room, (b) bridge and alternative steering position,

Helm indicator, protection of aft steering wheel and gear.

215 The main and auxiliary engines and boilers and electrical equipment are to be examined in accordance with the requirements of C 5 to C 11 and favourably reported on by the Society's Engineer Surveyors.

(B) At each Special Survey of ships between 5 and 10 years old.—THE FULL REQUIREMENTS OF 201 TO 215 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

216 A sufficient amount of ceiling in the holds and in coal bunkers is to be removed from the bilges and inner bottom to enable the condition of structure in the bilges, the inner bottom plating, pillar feet, and the bottom plating of bulkheads and tunnel sides to be examined. If the Surveyor deems it necessary, the whole of the ceiling is to be removed.

217 In ships having a single bottom the limber boards and ceiling equal to not less than three strakes all fore and aft on each side are to be removed, one such strake being taken from the bilges. Where the ceiling is fitted in hatches, the whole of the hatches and at least one strake of ceiling in the bilges are to be removed. If the Surveyor deems it necessary the whole of the ceiling and limber boards are to be removed.

218 Tanks (excluding peak tanks) used exclusively for oil fuel or for oil fuel and fresh water ballast need not all be examined internally provided, from an external examination and testing and from an internal examination of the after end of one forward double bottom tank, and of one selected deep tank, the Surveyor is satisfied with the condition.

Lubricating oil tanks need not be examined internally.

219 The chain cables are to be ranged for inspection, and the anchors and chains examined. If any length of chain cable is found to be reduced in mean diameter at its most worn part to the extent indicated in Chapter D, Table 55, it is to be renewed.

220 The chain locker is to be cleaned and examined internally.

(C) At each Special Survey of ships over 10 years old.—THE FULL REQUIREMENTS OF 201 TO 220 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

221 The steel work is to be cleaned and the rust removed.

222 Casings of air, sounding, steam and other pipes, spar ceiling and lining in way of the sidescuttles are to be removed as required by the Surveyor.

223 If the Surveyor is satisfied after removal of portions of the ceiling in the holds, that the steel work is in good condition, free from rust, and coated, the removal of the whole may be dispensed with. In coal bunkers, however, the whole of the ceiling is to be removed.

224 Attention is to be given by the Surveyor to the inside of coal bunkers and the parts in way of the boilers.

225 Attention is also to be paid to the possibility of local wastage and grooving, e.g., at the shell plating along the heel of framing members.

226 All double bottom and other tanks are to be cleaned as necessary to permit their being examined internally, where this is required.

For ships of 10 and not more than 15 years old, tanks (excluding peak tanks) used exclusively for oil fuel, oil fuel and fresh water ballast, or lubricating oil need not all be examined internally provided, from an external examination and testing and from internal examination of one double bottom tank forward and one aft and one deep tank, the Surveyor is satisfied with the condition.

For ships of 15 and not more than 20 years old, tanks (excluding peak tanks) used exclusively for oil fuel, oil fuel and fresh water ballast or lubricating oil need not all be examined internally provided, from an external examination and testing and from an internal examination of at least one double bottom tank amidships, one forward and one aft and one deep tank, the Surveyor is satisfied with the condition. These tanks should be selected so that as many different tanks as possible are examined internally before the ship is 20 years old. For ships 20 years old or over, all tanks should be examined internally, but in those ships operating on a Continuous Survey basis and fitted with nested deep tanks comprising six or more adjoining tanks, such tanks need not all be examined internally provided that at each year of the survey cycle one selected tank from each nest is found from internal examination to be in good condition.

227 The cement chocks on the ship's sides at bilges and decks are to be examined, and portions removed, so that the condition of the shell plating and adjacent steel work can be ascertained. Portions of wood sheathing, or other covering, on steel decks are to be removed as considered necessary by the Surveyor in order to ascertain the condition of the plating.

228 Where the holds are insulated for the purpose of carrying refrigerated cargoes, the limbers and hatches are to be lifted, and sufficient insulation is to be removed in each of the chambers to enable the Surveyor to satisfy himself of the condition of the framing and plating. (*See also* N 8.)

229 All mast wedging is to be removed and renewed as necessary.

(D) At the first Special Survey held after the ship is 24* years old and at every 12* years thereafter or at the next Special Survey after the expiration of the latter period—THE FULL REQUIREMENTS OF 201 TO 229 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

230 In addition to the drilling required by 205 to ascertain local wastage the shell plating and plating of strength decks are to be gauged by drilling or other approved means to determine the amount of any general diminution in thickness. The gauging is to be done in at least two places in each strake of plating on each side within the amidships half length, preferably clear of coal bunkers and deep tanks.

All paint and rust is to be entirely removed before the plates are gauged by the Surveyor and the actual thicknesses are to be reported in detail to the Committee. Where drilled plates are renewed the thickness of adjacent plates in the same strake should be reported.

The thickness of bottom plating in way of cement is to be ascertained unless the Surveyor, after an internal and external examination, is entirely satisfied that this is unnecessary. Selected portions of the cement are to be removed from the bottom and bilge if required by the Surveyor.

231 Where the holds are insulated for the purpose of carrying refrigerated cargoes, the limbers and hatches are to be lifted, and sufficient additional insulation is to be removed in each of the chambers to enable the Surveyor to satisfy himself of the condition of the steel structure, and to enable the thickness of the shell plating to be ascertained as required by 230.

* *For tankers see* C 307.

Section 3

SPECIAL SURVEYS—TANKERS

HULL REQUIREMENTS ADDITIONAL TO THOSE STATED IN C 2

Preparation and Inspection of Tanks

301 At all Special Surveys all cargo tanks and cofferdams are to be cleaned out, thoroughly cleared of gas, and examined. Every precaution is to be taken to ensure safety during inspection.

Attention is to be given to the inside of the bottom plating in order to ensure that there is no excessive pitting of the plating. When extensive pitting is found care should be taken to preserve the longitudinal strength of the bottom by the requisite renewals or repairs. In cases where cement has been laid in the bottom the Surveyor is to satisfy himself that there is no active corrosion under the cement.

302 The strums of the cargo suction pipes are to be removed to facilitate examination of the shell plating and bulkheads in that vicinity, unless other means for visual inspection of these parts are provided.

303 The attachment to the structure and condition of anodes in tanks is to be examined.

Testing

304 Each cargo tank bulkhead is to be tested at Special Surveys A and B by filling alternate tanks with water to the top of the hatchway. But at subsequent Special Surveys, or earlier if considered necessary by the Surveyor, all tanks are to be tested.

305 Tanks may be tested when the ship is afloat, provided the internal examination of the bottom is also carried out afloat.

306 Where extensive repairs have been effected to the shell plating, the tanks should be tested to the Surveyor's satisfaction.

Determination of Thickness

307 The thickness of shell and deck plating in way of tanks is to be ascertained by drilling or other approved means at the first Special Survey after the ship is 12 years old and at intervals of 4 or 8 years thereafter or at the next Special Survey after the expiry of these periods. The interval between the determination of the thickness will be regulated by the condition of the structure revealed at the survey and the repairs effected.

Section 4

LIQUEFIED GAS CARRIERS

ANNUAL AND SPECIAL SURVEYS—REQUIREMENTS ADDITIONAL TO THOSE STATED IN C 1, C 2 AND C 3.

Preparation before Survey

401 Prior to inspection of cargo tanks, cofferdams, associated piping, fittings or equipment, the respective items are to be cleaned and thoroughly cleared of gas. Every precaution is to be taken to ensure safety during inspection.

Annual Surveys

402 Where the maximum vapour pressure for which the cargo tanks have been approved as recorded in the Register Book is 0,7 kg. per cm.^{2}, or less, the inner surfaces of the tanks are to be examined annually.

Where submerged electrically driven pumps are fitted in the cargo tanks, the pumps, motors, control devices and interlocks are to be examined annually as required by 404.

Special Surveys

403 At each Special Survey of the ship the tanks are to be examined internally, also externally as far as practicable, particular attention being paid to the plating in way of supports and securing arrangements, mountings and pipe connections, also to sealing arrangements at the deck.

Where the tanks are insulated, portions of the insulation are to be removed if required by the Surveyor to enable him to ascertain the condition of the plating.

Internal fittings are to be examined, all valves and cocks in direct communication with the interiors of the tanks are to be opened out for inspection and any pipes connecting them to the tanks are to be examined internally so far as practicable.

Liquid level indicating devices, high level alarms, monitoring systems for revealing possible gas leakage and arrangements for inerting the tanks and containment spaces are to be examined and tested to ascertain that they are in good working order.

Where provision is made for recording the temperature of the ship's structure adjacent to the tanks, the correct functioning of the apparatus, including audible alarms, is to be verified.

Pressure relief valves are to be opened out for inspection and subsequently adjusted to lift at a pressure not more than three per cent above the maximum vapour pressure for which the tanks have been approved. The valves may be removed from the tanks for the purpose of making this adjustment which may be effected under pressure of air or other suitable medium.

Vacuum relief valves are to be opened out, examined and tested to establish that they are in good working order.

Where the approved maximum vapour pressure of the cargo tanks is 0,7 kg. per cm.^{2}, or less, the tanks are to be tested by a head of water 2,45 metres above the top of the tank or 610 mm. above the top of the hatch, whichever is the greater. Where access to the outside of the cargo tanks is not possible other proposals for leak testing of the cargo tanks will be considered.

Where the approved maximum vapour pressure is above 0,7 kg. per cm.^{2}, the tanks are to be tested by pressure of water equal to one and a quarter times the approved maximum vapour pressure. Where these tanks are insulated, at the second Special Survey and at each alternate Special Survey thereafter, the insulation is to be removed in way of all supports and connections to the tanks prior to the water pressure test.

Where non-corrosive cargoes only are carried in uninsulated cylindrical tanks fitted in the ship with their longitudinal axes approximately vertical and the cargoes are not discharged by the admission of water to the tanks, proposals will be considered, upon application by the Owners, to omit the hydraulic test provided the tanks have been constructed in accordance with Class I of the Rules for Welded Pressure Vessels, including stress relieving heat treatment, and the Surveyor is satisfied with their internal and external condition. Proposals to limit the amount of opening out of valves, cocks and pressure relief valves at each Special Survey will be considered provided all valves, etc., are seen in rotation in the course of each two consecutive Special Surveys.

Where insulation is attached to the hull structure, special consideration will be given to the necessity of removing it at Special Surveys but, in general, provided the Surveyor is satisfied that it is adhering properly and there are no traces of cold spots, this will not be required until the ship is at least eight years old. An examination of the wing tanks, double bottom tanks and transverse cofferdams, when the cargo tanks are loaded with liquefied gas at the minimum approved temperature, will be required at the Special Survey or at a convenient date immediately prior thereto.

404 Where submerged electrically driven pumps are fitted in the cargo tanks, at each Annual and each Special Survey the pumps and motors are to be withdrawn from the tanks and opened out for examination of the condition of the stator winding insulation, evidence of any damage due to thermal expansion and contraction and bearing wear. Any sludge deposits in the motor windings or casings are to be removed and insulation resistances, including those of the motors and supply cables, are to be measured before opening out and after refitting. The portions of supply cables within the cargo tanks and the cable glands are to be examined for signs of deterioration and/or gas leakage.

The control devices and interlocks actuated by pressure or liquid level in the tanks and master key switches, which cut off the supply of current to the motors, are to be checked under simulated working conditions and if necessary re-calibrated.

Where deep well pumps are fitted in the cargo tanks, at each Special Survey the control devices which cut off the supply of current to the motors are to be checked under simulated working conditions and if necessary re-calibrated.

405 Where refrigeration equipment is installed, either for maintaining the liquid cargo at the carrying temperature or for re-liquefying the "boil-off" and returning it to the tanks, a Special Survey of the equipment is to be carried out in accordance with the requirements of Chapter N for First and Subsequent Special Surveys, so far as applicable.

Section 5

GENERAL REQUIREMENTS—MACHINERY

Applicable to all Ships

At each Survey held in dry dock

501 When the ship is in dry dock the propeller, sternbush and sea connection fastenings and the gratings at the sea inlets are to be examined. The clearance in the sternbush or the efficiency of the oil gland should be ascertained.

Special Surveys—Machinery Requirements

502 At each Complete Survey required by B 807 the following parts are to be examined:—

Sea Connections

While the ship is in dry dock all openings to the sea in the machinery spaces and pump rooms with the valves, cocks and the fastenings with which these are connected to the hull.

Shafting

All shafts (except screw and tube shafts for which special arrangements are detailed in C 11), thrust block and all bearings. The lower halves of bearings need not be exposed if alignment and wear are found acceptable.

Reduction Gears, complete with all wheels, pinions, shafts, bearings and gear teeth.

Auxiliary Engines, auxiliary air compressors with their intercoolers, filters and/or oil separators and safety devices, and all pumps and components used for essential services.

Steering Machinery

Windlass.

Evaporators and their safety valves, which should be seen in operation under steam.

Securing Arrangements

The holding down bolts and chocks of main and auxiliary engines, gear cases, thrust blocks and tunnel bearings.

AIR RECEIVERS

All air receivers for essential services with their mountings, valves and safety devices are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to twice the working pressure.

PUMPING ARRANGEMENTS

The valves, cocks and strainers of the bilge system including bilge injection, are to be opened up as considered necessary by the Surveyor and, together with pipes, are to be examined and tested under working conditions. The oil fuel, feed and lubricating oil systems and the ballast connections and blanking arrangements to deep tanks which may carry liquid or dry cargoes, together with all pressure filters, heaters and coolers used for essential services, are to be opened up and examined or tested as considered necessary by the Surveyor. All safety devices for the foregoing items are to be examined.

FUEL TANKS AND FITTINGS

Fuel tanks which do not form part of the ship's structure are to be examined and if considered necessary by the Surveyor they are to be tested to the pressure specified for new tanks. The tanks need not be examined internally at the first survey if they are found satisfactory on external inspection. All mountings, fittings and deck controls are to be examined as far as practicable.

SPARE GEAR

The spare gear is to be checked.

BRIDGE, CENTRALISED AND AUTOMATIC CONTROLS

Where bridge, centralised or automatic controls are fitted for propulsion machinery, auxiliary machinery essential to the operation of the ship at sea, or for the cargo pumping systems of tankers, they are to be tested to demonstrate that they are in good working order.

In addition to the above, detailed requirements for steam and internal combustion engines, electrical installations and boilers are given in C 6, C 7, C 8 and C 9 respectively.

Section 6

STEAM ENGINES—DETAILED REQUIREMENTS

Complete Surveys

601 In addition to the requirements of C 5 the working parts of the main engines and attached pumps and of auxiliary machinery used for essential services including bulkhead stop valves, manœuvring valves, cylinders, pistons, valves and valve gear, piston rods, connecting rods, crossheads and guides, the crank shafts of reciprocating engines and the blading, rotors and casings of turbine machinery are to be opened up and examined.

Condensers, steam reheaters, desuperheaters which are not incorporated in the boilers and any other appliances used for essential services are to be examined to the satisfaction of the Surveyor, and if considered necessary they are to be tested.

The manœuvring of the engines is to be tested under working conditions.

602 Exhaust steam turbines supplying power for main propulsion purposes in conjunction with reciprocating engines are, together with their gearing and appliances, steam compressors or electrical machinery, to be examined as far as practicable. Where cone connections to internal gear shafts are fitted, the coned ends are to be examined as far as practicable.

603 In steam ships having essential auxiliary machinery driven by internal combustion engines, the prime movers of these auxiliaries are to be examined as detailed in C 701.

Section 7

INTERNAL COMBUSTION ENGINES—DETAILED REQUIREMENTS

Complete Surveys

701 In addition to the requirements of C 5 the Complete Survey is to consist of the opening out and examination of the following parts: cylinders, covers, valves and valve gear, fuel pumps and fittings, scavenge pumps, scavenge blowers and their prime movers, superchargers, compressors, their intercoolers, filters and/or oil separators and safety devices, pistons, piston rods, crossheads, guides, connecting rods, crank shafts and all bearings, clutches, reverse gears, attached pumps, cooling system, crankcase door fastenings and explosion relief devices. Selected pipes in the starting air system are to be removed for internal examination and hammer-tested. If an appreciable amount of lubricating oil is found in the pipes, the starting air system is to be thoroughly cleaned internally by steaming or other suitable means. Some of the pipes selected are to be those adjacent to the starting air valves at the cylinders and to the discharges from the air compressors. The electric ignition system, if fitted, is to be examined and tested. The manœuvring of engines is to be tested under working conditions.

Where steam is used for essential purposes, the condensing plant, feed pumps, and oil fuel burning plant, are to be examined and the steam pipes examined and tested as detailed in C 10.

702 Gas turbines and free piston gas generators: in addition to the requirements of C 5, the Complete Survey is to consist of the opening and examination of the following parts: the blading, rotors and casings of the turbines, the impellers or blading, rotors and casings of the air compressors, the combustion chambers, burners, intercoolers, heat exchangers, gas and air pressure piping and fittings, starting and reversing arrangements.

Where gas turbines operate in conjunction with free piston gas generators, the following parts of the latter are to be opened and examined: the gas and air compressor cylinders and pistons and the compressor end covers, the valves and valve gear, fuel pumps and fittings, synchronising and control gear, cooling system, explosion relief devices, gas and air piping, receivers and valves including by-pass. The manœuvring of engines is to be tested under working conditions.

Section 8

ELECTRICAL EQUIPMENT

801 At each Special Survey the electrical equipment is to be examined and tested in accordance with 802 to 811.

NOTE.—In cases where the Committee have consented to Continuous Surveys, the electrical equipment may also be included in the survey cycle. (*See* B 808.)

802 A test for insulation resistance is to be made on the cables, switchgear, generators, motors, heaters, lighting fittings, etc., and the insulation resistance is to be not less than 100,000 ohms between all insulated circuits and earth. The installation may be sub-divided to any desired extent by opening switches, removing fuses or disconnecting appliances for the purpose of this test.

803 The fittings on main and emergency switchboards, section boards and sub-distribution fuse boards are to be examined and over-current protective devices and fuses inspected to verify that they provide suitable protection for their respective circuits.

804 Generator circuit breakers are to be tested, as far as practicable, to verify that the protective devices including preference tripping relays, if fitted, operate satisfactorily.

805 The electric cables are to be examined as far as practicable without undue disturbance of fixtures or casings unless opening up is considered necessary as a result either of observation or of the tests required by 802.

806 The generator prime movers are to be surveyed as required by C 6 and C 7 and the governing of the engines tested. The motors concerned with essential services together with associated control and switch gear are to be examined and if considered necessary are to be operated as far as practicable under working conditions. All generators and steering gear motors are to be examined and are to be operated under working conditions though not necessarily under full load or simultaneously.

807 Where transformers or electrical apparatus associated with supplies to essential services are oil-immersed, the Owners are to arrange for samples of oil to be taken and tested for breakdown voltage, acidity and moisture by a competent testing authority and a certificate giving the test results is to be furnished to the Surveyor.

808 Where electro-magnetic couplings are fitted, the air gaps are to be measured and reported and any excessive eccentricity corrected. The couplings and associated switch gear are to be examined and tested.

809 Navigation light indicators are to be tried under working conditions and correct operation on the failure of supply and failure of navigation lights verified.

810 In passenger ships the emergency source of power and its associated circuits and, where fitted, the temporary source of power and its automatic arrangements are to be tested. (*See* M 111).

In cargo ships the emergency source of power and its associated circuits are to be tested. (*See* M 111).

Electric Propelling Machinery

811 Where the ship is electrically propelled, the propulsion motors, generators, cables, and all ancillary electrical gear, exciters and ventilating plant (including coolers) associated therewith are to be examined and the insulation resistance to earth is to be tested. Special attention is to be given to windings, commutators and slip-rings. The operation of protective gear and alarm devices is to be checked as far as practicable. Insulating oil, if used, is to be tested in accordance with 807. Interlocks intended to prevent unsafe operations or unauthorised access are to be checked to verify that they are functioning correctly. Emergency overspeed governors are to be tested.

Section 9

BOILER SURVEYS

901 All boilers, including exhaust gas or steam heated steam generators, economisers, domestic boilers having a working pressure exceeding 3,5 kg. per cm^2, and a heating surface exceeding 4,65 square metres, also press boilers and similar apparatus in floating whale oil factories are to be surveyed at two-yearly intervals until they are 8 years old and subsequently annually. In fired boilers employing forced circulation the pumps used for this service are to be opened and examined at each boiler survey.

902 At the surveys described in 901 the boilers, superheaters, economisers and air heaters are to be examined internally and externally and where considered necessary the pressure parts are to be tested by hydraulic pressure and thickness of plates and tubes and size of stays are to be ascertained to determine a safe working pressure. The principal mountings on boilers, superheaters and economisers are to be opened up and examined and the safety valves adjusted under steam to a pressure not greater than 3 per cent above the approved working pressures of the respective parts. The remaining mountings are to be examined externally and are to be opened up for internal examination if considered necessary by the Surveyor. Collision chocks, rolling stays and boiler stools are to be examined and maintained in efficient condition.

903 The oil fuel burning system is to be examined under working conditions and a general examination made of fuel tank valves, pipes, deck control gear and oil discharge pipes between pumps and burners.

904 At each survey of a cylindrical boiler which is fitted with smoke tube superheaters, the saturated steam pipes are to be examined as detailed in C 1004.

Section 10

STEAM PIPES

Steel Pipes

1001 Incidence of Surveys.—Saturated steam pipes, also superheated steam pipes where the temperature of the steam at the superheater outlet is not over 454° C., are to be surveyed at the second and each subsequent Special Survey. Superheated steam pipes where the temperature of the steam at the superheater outlet is over 454° C. are to be surveyed at each Special Survey, including the first.

Scope of Surveys

1002 Pipes Having Bolted Joints.—At each survey a selected number of main steam pipes, also of auxiliary steam pipes over 75 mm. internal diameter supplying steam for essential services at sea, are to be removed for internal examination and hydraulically tested to twice the working pressure. If these selected pipes are found satisfactory in all respects, the remainder need not be tested. The pipes are, so far as practicable, to be selected for examination and hydraulic test in rotation so that in the course of surveys all sections of the pipeline will be tested.

1003 Pipes Having Welded Joints.—Where main and/or auxiliary steam pipes of the category described in 1002 have welded joints between lengths of pipe and/or between pipes and valves, the lagging in way of the welds is to be removed, the welds examined and, if considered necessary by the Surveyor, crack detected. Plugs fitted in the piping for inspection purposes are to be removed and the piping examined internally as far as practicable by introscope or other optical means and, after the plugs have been replaced, the pipe lines are to be tested hydraulically to twice the working pressure. Where lengths having ordinary bolted joints are fitted in such pipe ranges and can be readily disconnected, they are to be removed for internal examination and hydraulically tested to twice the working pressure.

1004 Cylindrical Boilers Having Smoke Tube Superheaters.—Where the saturated steam pipes adjoining the saturated steam headers are situated partly in the boiler smoke boxes, all such pipes adjoining and cross-connecting these headers in the smoke boxes are, at the surveys required by 1001, to be included in the pipes selected for examination and testing as defined in 1002. Where the saturated steam pipes inside the smoke boxes consist of steel castings of substantial construction, these requirements need only be applied to a sample casting. Where steel castings are not fitted, the Surveyor is to satisfy himself of the condition of the ends of the saturated steam pipes in the smoke boxes *at each boiler survey* and, if he considers necessary, a sample pipe is to be removed for examination.

1005 As an alternative to the requirements of 1002, and provided the saturated steam pipes in smoke boxes are dealt with as detailed in the first paragraph of 1004, the remainder of the pipes may, if the Owner wishes, be hydraulically tested in place to twice the working pressure. Lagging is to be removed as required by the Surveyor to permit effective examination.

Copper Pipes

1006 At the second and at each subsequent Special Survey all copper steam pipes over 75 mm. internal diameter supplying steam for essential services at sea are to be hydraulically tested to twice the working pressure. At these surveys any of the pipes which may be subject to bending and/or vibration, such as those having expansion or other bends, and closing lengths adjacent to steam driven machinery, are to be annealed before being tested.

Section 11

SCREW SHAFTS AND TUBE SHAFTS

1101 Screw shafts and tube shafts are to be drawn periodically for examination by the Society's Surveyors.

Where shafts are fitted with continuous liners or approved oil glands, or are made of approved corrosion-resisting material, they normally become due for survey at intervals of 3 years for single screw ships and 4 years for ships having two or more screws. All other shafts should be drawn at intervals of 2 years.

1102 On the application of Owners, surveys of shafts of single screw ships having continuous liners or approved oil glands, or made of approved corrosion-resisting material may be held at intervals of 4 years, provided the keyway is of the sled-runner or round-ended type having adequate root radius, any sharp edge

around the keyway at the surface of the shaft is removed by filing or other suitable means and, at each survey, the shaft is examined by an efficient crack detection method over a length from the after end of the liner (or after end of the stern tube for shafts not fitted with continuous liners) to a position at about one-third of the length of the cone from the large end. Upon application by the Owners and provided the keyway is as described above, a four-year period will also be allowed before the first survey of the shaft of a new single screw ship and may be allowed for a new or previously unused spare shaft fitted to an existing ship. At the first and subsequent periodical surveys the forward portion of the shaft cone is to be examined by an efficient crack detection method.

1103 The Committee will be prepared to give consideration to the circumstances of any special case upon application by the Owners.

Section 12

CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY

1201 When classification is desired for a ship not built under the supervision of the Society's Surveyors, application should be made to the Committee in writing.

Hull and Equipment

1202 Plans showing the main scantlings and arrangements of the actual ship and any proposed alterations are to be submitted for approval. These should comprise midship section, longitudinal section and decks, and such other plans as may be requested. If plans cannot be obtained or prepared by Owners, facilities are to be given for the Society's Surveyor to take the necessary information from the ship.

Particulars of the process of manufacture and testing of the material of construction should be furnished.

1203 In all cases the full requirements of C 201 to C 229 are to be carried out. In the case of tankers the requirements of C 301 to C 306 are also to be carried out. Tankers over 12 years old are in addition to comply with C 307, and other ships over 20 years old with C 230 and C 231. During the survey the Surveyors are to satisfy themselves regarding the workmanship and verify the approved scantlings and arrangements. For this purpose, and in order to ascertain the amount of any deterioration, parts of the structure will require to be drilled as necessary. Full particulars of the anchors, chain cables and equipment are to be submitted. Fire protection, detection and extinction are to be in accordance with the Rules (*see* Chapter F).

Ships of recent construction will receive special consideration.

1204 When the full survey requirements indicated above cannot be completed at one time, the Committee may consider granting an interim record for a limited period. The conditions regarding the completion of the survey will depend on the merits of each particular case, which should be submitted for consideration.

Machinery

1205 To facilitate the survey, plans of the following items, together with the particulars of the materials used in the construction of the boilers, air receivers and important forgings should be furnished:—

General pumping arrangements, including air and sounding pipes. (Shipbuilder's plan.)
Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.
General arrangement of cargo piping in tanks and on deck of oil tankers.
Piping arrangements for cargo oil (F.P. above 65,5° C.).
Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service.
Arrangement and dimensions of main steam pipes.
Arrangement of oil fuel pipes and fittings at settling and service tanks.
Arrangement of oil fuel piping in connection with oil burning installations.

Oil fuel and cargo oil overflow systems, where these are fitted.
Arrangement of boiler feed systems.
Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.
Plans of machinery space piping are to be diagrammatic.
Boilers, superheaters and economisers.
Air receivers.
Crank, thrust, intermediate and screw shafting.
Clutch and reversing gear with methods of control.
Reduction gearing.
Electrical circuits.

NOTE.—Plans additional to the above should not be submitted unless the machinery is of a novel or special character affecting classification.

Where centralised, bridge or automatic controls are fitted to propulsion machinery and essential auxiliaries, a description of the scheme is to be submitted. Particulars are to be given of the spare gear carried for machinery and control gear and whether maintenance is by repair or replacement.

TORSIONAL VIBRATION CHARACTERISTICS

For new ships and ships which have been in service less than 8 years calculations of the torsional vibration characteristics of the propelling machinery are to be submitted for consideration as required for ships constructed under Special Survey. For older ships the circumstances will be specially considered in relation to their service record and type of machinery installed.

Where calculations are not submitted the Committee may require that the machinery certificate be endorsed to this effect.

When desired by the Owners the calculations and investigation of torsional vibration characteristics of machinery may be carried out by the Society upon special request.

1206 The main and auxiliary machinery, also feed pipes, compressed air pipes and boilers are to be examined as required at Special Surveys, and their working pressures are to be determined from their actual scantlings in accordance with the Rules.

The screw shaft is to be drawn and examined.

The steam pipes are to be examined and tested as required by C 10.

The bilge, ballast and oil fuel pumping arrangements are to be examined and amended as necessary to comply with the Rules.

Oil burning installations are to be examined as required at Special Surveys and found, or amended, to comply with the requirements of the Rules ; they are also to be tested under working conditions.

The electrical equipment is to be examined as required at Special Surveys.

The spare gear is to be in accordance with the Rules.

The whole of the machinery, including essential controls, is to be tried under working conditions to the Surveyors' satisfaction.

First entry reports are to be prepared by the Surveyors.

1207 Where classification with the Society is desired for a ship which is classed by another recognised Society, special consideration will be given to the scope of the machinery survey.

Periodical Surveys

1208 Periodical surveys are subsequently to be held as in the case of ships built under survey.

16th June, 1966

NOTE

Chapter D, Sections 1 to 9 inclusive, 11, 12, 14, 15, 16, 18 to 21 inclusive, 26 and 34 of these Rules are only applicable to cargo ships of 100 metres in length and under. For vessels exceeding 100 metres in length, see Notice No. 5 to the 1966 Rules.

Chapter D

STEEL SHIPS

Section 1 (*See* Note on page 29)

GENERAL

Determination of Scantlings

101 The scantlings in the Tables are related in general to basic dimensions and, where necessary, to a basic moulded draught. Corrections are given in the Tables, or associated notes, for use where the actual dimensions or draught of the ship differ from those in the Tables. The Rules and Tables are framed for ships of normal ratio of breadth to depth and having proportions of length to depth at the strength deck not exceeding thirteen and a half.

If the proportions are abnormal, special structural arrangements will be required.

The minimum scantlings given by the Tables may require to be increased on account of particular features in general design or when Owners desire to make provision for exceptional distributions or concentration of loading (*see* B 101, D 34, D 37 and Table 18, note 2 (*e*)).

The scantlings and arrangements in passenger ships will be specially considered in relation to the general design features.

Assignment of Class

102 The Class 100A1 will be assigned in accordance with the provisions of Chapter B to all sea-going ships when the requirements of the Rules have been complied with for the draught required.

Material

103 The Rules and Tables are based on the use of mild steel which complies with the requirements of Chapter P. Grade A steel (*see* P 2 Table II) may be used except where a higher grade is specifically required. As an alternative to Grade D, Grade C may be accepted, subject to compliance with the impact test requirements of Grade D. In special circumstances impact tests may not be required.

Where the physical characteristics of the steel are in excess of the requirements of P 2, or other material is used, the scantlings will be specially considered. For scantling reductions when higher tensile steel complying with P 219 to P 227 is used, *see* D 65, D 66 and D 67.

The minus tolerance in the thickness of plates and sections from those given on the approved plans is not to exceed 2 per cent. For plates below 25 mm. in thickness a plate edge thinning up to 0,5 mm. may be accepted if the average thickness of the plate is within the above minus tolerance limit.

The general standard as laid down by the Rules is to be maintained.

Method of Construction

104 The Rules and Tables set forth requirements for riveted construction together with certain modifications where electric arc welding is adopted.

Particulars indicating the principal parts which are electrically welded will be given in the Register Book as deemed desirable by the Committee.

Interpolation

105 For dimensions and draughts between the values given in the Tables the scantlings are to be obtained by interpolation.

Distribution of Material

106 The scantlings given in the Tables for the midship portion of the ship are to be reduced gradually to those given for the ends.

Equivalents

107 Alternative arrangements or fittings which are considered to be equivalent to the requirements of the Rules will be accepted by the Committee but the Owners' sanction may be required.

Submission of Plans

108 For each ship proposed to be built under survey for classification in the Register Book plans of midship and longitudinal sections, on which the designed summer

moulded draught is to be given together with the particulars necessary for calculation of freeboard, are to be submitted for approval.

The following plans are also to be submitted:—

Shell plating.

Decks.

Watertight bulkheads.

Pillars and girders.

Deep tanks.

Oil fuel bunkers.

Arrangements to resist panting.

Strengthening of bottom forward.

Rudder and sternframe.

Propeller brackets.

Bossed framing.

Motor and thrust seating.

Cruiser stern.

Long deckhouses.

Hatchways.

Main steering gear of rod and chain type and auxiliary steering gear.

Strengthening for navigation in ice.

Pumping arrangements.

Scheme of riveting.

Scheme of welding.

NOTE.—*It is recommended that a plan be carried in the ship indicating the positions and grades (other than Grade A) of hull structural steel, for the convenience of all concerned with repairs and renewals. This may be done by colouring the plan according to P 202, or by other appropriate means.*

Corrosion Control

109 Where an approved system of corrosion control is fitted in deep tanks, double bottom tanks, topside tanks, hopper side tanks, side ballast tanks, or oil fuel bunkers, the reductions in thickness given below will be allowed.

Cathodic protection may be adopted for water ballast tanks, but if reductions are desired at the top of a deep tank within 1,525 metres of the deckhead, this part of the tank is to be coated.

Where reductions are desired, full particulars of the protection proposed are to be submitted and the plans are to show both the rule and the reduced scantlings. An appropriate notation may be made in the Register Book.

Item	*Permissible reduction in thickness*
All structural items wholly within the protected tank with the exception of longitudinals on the bottom, side, strength deck, and on other longitudinal strength members.	10%
Items of which one side only is within the protected tank, e.g., transverse bulkhead at end of deep tank, tank top plating, etc. (*see* Note 1). Longitudinals on the bottom, side, deck and on other longitudinal strength members. Keel (*see* Note 2). Bottom shell (*see* Note 2). Side shell (*see* Note 2). Deck plating (*see* Note 2).	5%

NOTES.—1. The tank top, and lower strakes of longitudinal and transverse bulkheads where liable to suffer grab or bulldozer damage only to be reduced by 5 per cent even if protected on both sides.

2. Reduction not affected by means of external protection.

Section 2 (See Note on page 29)

DEFINITIONS

201 Length L is the distance in metres on the summer load waterline from the fore side of stem to the after side of rudder post, or to the centre of rudder stock if there is no rudder post. L is not to be less than 96 per cent, and need not be greater than 97 per cent, of the extreme length on the summer load waterline.

Amidships is to be taken as the middle of the length L, measuring from the fore side of the stem.

In ships with unusual stern arrangements, the length L will be specially considered.

202 Breadth B is the greatest moulded breadth in metres.

203 Depth D is measured in metres at the middle of the length L from top of keel to top of deck beam at side.

D for shell and topside plating is measured to the strength deck as defined in 207.

D for framing is measured to the uppermost continuous deck.

204 Draught d is the summer draught in metres measured from top of keel.

205 Depth h for Framing is measured in metres from the top of the double bottom or single bottom floor at side to the top of beam at side of the lowest deck.

206 Effective Superstructure is a midship superstructure extending from side to side of the ship and exceeding 0,15L in length.

207 Strength Deck is the uppermost continuous deck except in way of an effective superstructure where the superstructure deck is to be considered the strength deck.

208 Passenger ship is a ship, engaged on international voyages, which carries more than twelve passengers.

Section 3 (*See* Note on page 29)

KEELS, STEMS AND STERNFRAMES

Materials

301 Steel castings are to comply with the requirements of P 5.

302 Forgings made of ingot steel are to comply with the requirements of P 6.

303 If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

Plate Keels

304 The scantlings of plate keels are given in Table 14, note 1. Plate keels are to be associated with centre keelsons or centre girders as required by D 4 or D 5.

Bar Keels

305 The scantlings of bar keels are given in Table 1.

Riveted scarphs connecting the separate lengths together, or to the stem and sternpost, are to have a length of nine times the thickness of the bar.

Stems

306 Bar stems are to have the scantlings given in Table 1, but above the load waterline the dimensions may be gradually tapered to the stem head where the sectional area may be 75 per cent of the area derived from the Table.

307 If the stem is constructed of shaped plates the thickness of the plates below the load waterline is to be 10 per cent greater than the thickness of the side shell plating given in Table 14, col. 6, without corrections; above the load waterline the thickness may be gradually tapered towards the stem head where it may be equal to the shell plating at ends. Plates which require to be furnaced are to have these thicknesses when finished.

The plates are to be supported by horizontal webs between the decks and below the lowest deck; the unsupported length of the stem plates is not to exceed 1,5 metres. Where the radius of the plates is large a centre line stiffener may be required.

For strengthening of plate stems for navigation in ice, *see* D 1013, D 1014, D 1025, D 1032 and D 1039.

308 The separate lengths of the stem are to be efficiently connected and the lower end of a bar stem is to overlap the forward flat keel plate.

Sternframes

309 Sternframes may be of rectangular or streamlined section or may be of built construction to suit the lines of the ship. The scantlings are to be determined from Tables 2 and 3 and associated notes. Cast steel and built sternframes are to be strengthened at intervals by transverse webs of suitable thickness. Cast steel sternframes are to be simple in design and all fillets should have a large radius.

310 The lower part of the sternframe is to be extended forward to provide an efficient connection to the flat plate keel.

311 The rudder post is to be attached to a transom plate of the same depth as that required for double bottom floors and 2,5 mm. thicker than the floors (*see* Table 6, cols. 4 and 10); when the length of the ship exceeds 91,5 metres the rudder post is to be connected to the transom by double angles, double riveted in each flange. In single screw ships having cruiser sterns or exceeding 91,5 metres in length the propeller post is to be efficiently attached to a deep floor.

312 The sole piece under a propeller aperture is to be kept as short as possible and is to be increased in scantlings as required by Table 2, note 4.

313 The upper gudgeon is to be as near as practicable to the rudder trunk and rudder coupling. Gudgeons are to have a thickness of metal round the finished bore equal to half the diameter of the pintle and the depth is to provide full bearing surface for the pintle. The scantlings of pintles are to be determined from Table 47 and associated notes.

314 The length of the scarph in a sternframe of rectangular section is to be three times the fore and aft dimension of the post and the width of the scarph is to be half the length of the scarph. The thickness at the tip of the scarph is to be 13 per cent of the thickness of the post, and the connection is to be made by four rows of rivets. In single screw ships the scarph of the rudder post should not be fitted above the upper gudgeon. The strength of scarphs or other connections in cast steel streamlined sternframes is to be equivalent to the above requirements.

315 The scantlings and arrangements of propeller brackets and of sternframes in ships of relatively high power will be specially considered.

Cross-reference

316 For riveted connections to stems and sternframes, *see* Table 52 H.

Section 4 (*See* Note on page 29)

SINGLE BOTTOMS

Floor Plates

401 The scantlings of floor plates are to be determined from Table 4 and associated notes. Floors are to be fitted at every frame.

If a bar keel is fitted the floors are to be continuous from side to side; if a flat plate keel is adopted the floors may be continuous or cut at the centre line.

402 The floors at the bilges are to be attached to the frames by flanged brackets of the same thickness as the floor plates and having breadth and depth, clear of the frame and floor respectively, equal to the depth of the floor at the centre line.

Alternatively, the brackets may be omitted if the depth of the floor is increased by 15 per cent and the frame is reinforced at its junction with the floor plate.

403 The tops of floors are, in general, to be level from side to side but in ships having considerable rise of floor, and in all ships in the engine room and towards the ends, the depth of the floor plates is to be increased; the brackets may be dispensed with provided the side framing is adequately supported.

404 Floor plates forming part of a bulkhead are to be not less than 900 mm. in depth measured at the centre line and the thickness is to be as required for the bottom strake of the bulkhead.

405 The side frames are to be efficiently attached to the floor plates.

Frames and Reversed Frames

406 Floors are to be attached to the bottom plating by single angles having the same thickness as the floor plates. (*See* D 807.)

407 Reversed frames on the upper edges of the floor plates are to have the scantlings given in Table 4.

Throughout the engine room, under the boiler bearers and in way of strengthening of bottom forward, the reversed frames are to be doubled from side to side.

Centre Keelsons

408 The scantlings of centre keelsons are given in Table 5. The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

409 In ships having a bar keel, the centre keelson is to consist of continuous double angles on top of the floors in conjunction with intercostal plates connected to the floors by single angles having the same thickness as the intercostal plates.

In ships not exceeding 50 metres in length the intercostal plates may be omitted provided the centre keelson bars are as required by Table 5 for tugs.

410 Plate keels are to be associated with plate keelsons having double continuous top angles. The keelson plates are to be connected to the keel by single angles except in the engine room, thrust recess and the forward 0,25L where the connection is to be double. If the floors are continuous the keelson plates are to be intercostal and attached to the floors by single angles having the same thickness as the intercostal plates.

Where the floors are cut at the middle line they are to be connected to the continuous keelson plate by double angles having the thickness of the keelson plates. Continuous foundation plates are to be fitted at the top of the floors on each side of the keelson plate.

411 The butts of all continuous longitudinal material are to be efficiently strapped or welded.

Side Keelsons

412 The scantlings of side keelsons are given in Table 5. The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

413 One side keelson is to be fitted on each side of the centre line if the breadth B does not exceed 9,15 metres and two where B is above 9,15 metres and does not exceed 16,45 metres.

414 The keelsons are to consist of a continuous angle with the wider flange laying on the reversed frames.

Intercostal plates fitted between the floors are to be attached to the continuous angles and connected to the shell plating by single angles having the same thickness as the intercostal plates.

415 The butts of the continuous angles are to be efficiently strapped or welded.

416 In the engine room additional side keelsons are to be fitted.

Increased Thicknesses in Machinery Spaces

417 In the engine room the floors are to be increased in thickness by 1 mm.

In the boiler room the floors, reversed frames, centre and side keelson plates and all angles not covered by cement are to be increased in thickness by 2,5 mm.

Strengthening of Bottom Forward

418 The bottom structure forward is to be in accordance with the requirements of D 8.

Ships Loading or Discharging Aground

419 It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

Pumping and Drainage

420 The arrangements are to be in accordance with the requirements of Chapter E. Efficient provision is to be made to permit water from every part of the bottom to reach the pump suctions.

Section 5 (See Note on page 29)

DOUBLE BOTTOMS

Scantlings

501 The scantlings of the double bottom structure and the tank side connections are to be determined from Tables 6 to 11 and associated notes.

Centre Girder

502 The attachment of the centre girder to the keel plate and to the middle line strake of the inner bottom is to be by double angles, or equivalent connections, throughout in all ships exceeding 106,7 metres in length; in smaller ships the attachment need be double, or equivalent, only in the engine room, thrust recess and in the forward 0,25L.

Intercostal Side Girders

503 In ships where the breadth B does not exceed 10,4 metres one stiffener is to be fitted to the floors on each side, about midway between the centre line and the margin plate. Where B exceeds 10,4 metres one intercostal side girder is to be fitted and where B exceeds 19,5 metres but does not exceed 24,4 metres two girders are to be fitted on each side of the centre line extending as far forward and aft as practicable. In the forward 0,25L of all ships side girders are to be fitted as required by D 805.

504 In the machinery space and thrust recess the number and disposition of the side girders are to be such as to support the machinery effectively and to secure the necessary rigidity of structure. Double angles or equivalent connections are to be fitted on the upper edges of these girders under the engines and thrust seating.

505 Intercostal girders are not to be flanged in the forward 0,25L under the engine and thrust seating or under widely spaced pillars. Where intercostals are flanged their thickness is to be increased by 10 per cent.

506 If plate floors are fitted at every frame the intercostal girders, except in the engine room and in the forward 0,25L, may be replaced by continuous bulb angles on the shell and inner bottom, having the scantlings given in Table 10 for a span of 1,25 metres. These bulb angles are to be attached to the floors by vertical angles extending for the full depth of the floors and having the same depth as the bulb angles, but these angles need not exceed 150 mm. in depth. The thickness of the vertical angles may be the same as that of the floors.

Riveting at each end of the vertical angles is to be as required by Table 8, cols. 4 and 5.

Plate Floors

507 Plate floors are to be fitted at every frame in the engine room and in the forward 0,25L; they are also to be fitted under the boiler bearers, bulkheads, toes of brackets to deep tank bulkhead stiffeners and in way of any change in depth of double bottom. Partial plate floors are to be fitted under the thrust seating.

The floors under the engine room, thrust seating and boiler bearers are to have double angles or equivalent attachments to the centre girder; elsewhere the connections may be single. The reversed frames on the floors may be single except under the engine room from the centre line to the girder outside the engine seating, under the thrust seating and from side to side under boiler bearers.

508 Except as required by 507, plate floors may be spaced not more than 3 metres apart, and the shell and inner bottom plating between these floors is to be supported by bracket floors. Alternatively a system of longitudinal framing may be adopted—*see* 517 to 523.

509 Floors are not to be flanged.

510 Watertight floors are to be fitted below or in the vicinity of watertight bulkheads and their thickness is to be 2 mm. greater than that given in Table 6, col. 10, but need not exceed 13,5 mm. If the depth of the centre girder exceeds 915 mm. the floors are to be fitted with stiffeners, of scantlings given in Table 9, spaced 760 mm. apart; the ends of the stiffeners are to extend to the toes of the boundary angles.

511 Additional stiffening is to be fitted under the heels of widely spaced pillars as required by D 1516 to D 1523.

512 In ships from which the cargo is to be regularly discharged by grabs, it is recommended that plate floors be fitted at every frame.

Bracket Floors

513 The scantlings of the bottom frames and reversed frames are to be determined from Table 7 and associated notes.

514 The breadth of the brackets attaching the frames and the reversed frames to the centre girder and margin plate is to be three-quarters of the depth of the centre girder; the brackets are to be flanged on the unsupported edge and are to have the same thickness as the plate floors.

515 The frames and reversed frames are to be attached to the side girders by angles having the same depth as the reversed frames, but these angles need not exceed 150 mm. in depth. The thickness of the vertical angles may be the same as that of the floors.

Struts, if fitted to reduce the unsupported span of the frames and reversed frames, are to have the scantlings given in Table 8. Where the struts are welded the area is to be at least 80 per cent of that given in Table 8, col. 6, provided their stability and end connections are adequate.

516 Details of riveted connections in bracket floors are given in Table 8.

Longitudinal Framing

517 Where longitudinal framing is adopted in the double bottom the scantlings of the longitudinals are to be as given in Table 10 and associated notes.

518 Plate floors are to be fitted at every frame under the main engines and the foremost shaft tunnel bearing and at alternate frames outside the engine seating or equivalent arrangements are to be provided.

Plate floors are also to be fitted under boiler bearers, bulkheads, and the toes of brackets of deep tank bulkhead stiffeners.

Elsewhere the spacing of the floors is not to exceed 3,65 metres or 0,05L and the thickness of the floors is to be increased 10 per cent beyond that required by Table 6.

The longitudinal girders under the main machinery are to extend for the full length of the machinery space and are to be carried aft to support the foremost shaft tunnel bearing; this extension abaft the after engine room bulkhead is to be at least three transverse frame spaces. At the fore end of the engine room the girders are to be tapered off over three transverse frame spaces and are to be efficiently scarphed into the longitudinal framing system.

519 The floors are to be attached to the shell and inner bottom by double angles or equivalent for two spaces of longitudinals at each end of the floor plate. The floors are to be attached to the centre girder and margin plate by double angles single riveted, or equivalent, except where the spacing of the floors exceeds 2,45 metres when the attachment to the centre girder is to be by double angles double riveted.

520 The unsupported span of the longitudinals is not to exceed 2,45 metres. In longer spans struts of the same scantlings as required for bracket floors (Table 8) are to be introduced and attached to the longitudinals by the number of rivets given in the Table. The scantlings of the longitudinals at shell and inner bottom adjacent to the centre girder and margin plate may be based on a span of 1,25 metres.

The shell and inner bottom longitudinals are to be attached to the floors by means of vertical angles extending from the shell to the inner bottom having the same depth as the inner bottom longitudinals, but these angles need not exceed 150 mm. in depth; they are to be riveted as required by Table 8. The thickness of the vertical angles may be the same as that of the floors.

Where longitudinals are cut at watertight floors they are to be attached to the floors by brackets of a width on each arm equal to three times the depth of the shell longitudinals, of the thickness given in Table 6, col. 10 or 11, and riveted as required by Table 8, cols. 7 and 8.

521 An intercostal side girder, as required by 503 to 505, is to be fitted on each side where B exceeds 13,7 metres and two side girders on each side where B exceeds 21,3 metres.

522 Between plate floors, transverse brackets of the thickness required by Table 6, col. 10 or 11, are to be fitted extending from the centre girder and margin plate to the adjacent longitudinal. The brackets, which are to be flanged, are to be fitted at every frame at the margin plate and those at the centre girder are to be spaced not more than 1,2 metres apart.

523 Where, at the ends of the ship, the longitudinal system of framing is replaced by a transverse system adequate arrangements are to be made to avoid abrupt discontinuities.

Inner Bottom Plating and Margin Plates

524 The inner bottom plating is to be of the thickness given in Table 6 and is to be increased by 2 mm. under the hatchways if no ceiling is fitted; the thickness of the middle line strake is not to be less than that of the increased inner bottom plating.

The margin plate is to have the thickness given in Table 6 and is to be of the depth amidships required by Table 6, note 2.

525 If cargo is to be regularly discharged by grabs, or similar means, it is recommended that double ceiling should be fitted or the thickness of the plating increased 5 mm. and fitted with a flush surface.

For recommendations for thickness of tank top plating when fork lift trucks are to be used, *see* D 1108.

526 In passenger ships, the inner bottom plating is to be continued out to the ship's side in such a manner as to protect the bottom to the turn of bilge. Such protection will be deemed satisfactory if the line of intersection of the outer edge of the margin plate with the bilge plating is not lower at any part than a horizontal plane passing through the point of intersection with the frame line amidships of a transverse diagonal line inclined at 25 degrees to the base line and cutting it at a point one half the ship's moulded breadth from the middle line.

Manholes and Lightening Holes

527 Sufficient manholes are to be cut in the inner bottom, floors and side girders to provide adequate ventilation and access to all parts of the double bottom and the edges of the holes are to be smooth. No manholes are to be cut in the floors or girders under widely spaced pillars.

528 Where manhole covers are attached by bolts to the inner bottom plating, doubling plates or rims are to be fitted to take the fastenings of the covers. Manhole covers which project above the inner bottom plating are to be adequately protected.

Tank Side Brackets and Margin Connections

529 The height and thickness of the tank side brackets are given in Table 11. The free edges of the brackets are to be flanged or otherwise stiffened.

At the ends of the ship where the form of the brackets may become unduly elongated, the arrangements will be specially considered.

530 Riveted attachments of the tank side brackets to the frames and margin plate are given in Table 11. The angles attaching the floors to the margin plate are to have the same number of rivets in both flanges as the angle to the tank side brackets, and the inner and outer angles are to be through riveted.

If gusset plates are fitted they are to be not more than three frame spaces apart; if the number of rivets required in the gusset is more than six per frame space the gusset is to be fitted at every frame or is to be a continuous plate. Gussets are to be so spaced that each will require not less than three rivets.

531 If the margin plate is approximately horizontal the strength of the margin connection will be specially considered.

532 For increases in the panting region, *see* D 906.

Increased Thicknesses in Machinery Spaces

533 In the boiler room and donkey boiler recess the floor plates and brackets, centre and side girders, inner bottom plating, margin plate, tank side brackets, gussets and all rolled sections not covered by cement, and in the engine room the inner bottom plating, are to be increased in thickness as required in Tables 6 to 11 and associated notes.

534 Where machinery is fitted aft, the thicknesses of the inner bottom plating in the boiler room are to be increased by the increments which would have been added if the machinery had been fitted amidships; in the engine room this thickness is to be as given in Table 6, col. 18.

Strengthening of Bottom Forward

535 The bottom structure forward is to be in accordance with the requirements of D 8.

Ships Loading and Discharging Aground

536 It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

Oil Fuel

537 If oil fuel is to be carried in double bottoms the provisions of D 2020 and D 2021 are to be complied with.

Where refrigerated cargoes are to be carried, *see* D 2022 and D 2023.

Pumping and Drainage

538 The arrangements are to be in accordance with the requirements of Chapter E.

539 Ample provision is to be made for the free passage of air and water from all parts of the tanks to the air pipes and suctions.

Caulking and Water Testing

540 The double bottom is to be caulked and made watertight, but the centre girder need not be caulked or tested.

Each compartment on completion is to be tested with a head of water representing the maximum pressure which could be experienced in service.

Cross-reference

541 For additional stiffening under heels of pillars, *see* D 1520.

Section 6 (*See* Note on page 29)

SIDE FRAMING

Scantlings

601 The scantlings of the main, peak and 'tween deck frames are to be determined from Tables 12 and 13 and associated notes.

The depth D for use in the Tables is defined in D 203.

602 The scantlings given for the framing in the various 'tween decks represent the minimum standard, but the system is to be so arranged that continuity is maintained.

603 Where holes are drilled or punched in the inboard flange of channel or similar hold frames, the scantlings may have to be increased.

Frame Spacing

604 The spacing of the frames, except in the regions defined in 605 and 606, may be as given in Tables 12 and 13.

605 Frame spacing in peaks and cruiser sterns is not to exceed the Table spacing or 610 mm., whichever is less.

606 Frame spacing between 0,2L from forward and the collision bulkhead is not to exceed the Table spacing or 685 mm., whichever is less.

607 Where the spacings adopted differ from those set forth in 604 to 606, the scantlings of the main and 'tween deck frames are to be corrected as required by the notes.

Main Framing

608 The depth h to be used in Table 12 is defined in D 205, and is to be measured:

At amidships, for framing between the after peak bulkhead and 0,25L from the fore end.

At 0,25L from the fore end, for framing between that point and 0,15L from the fore end.

As required by D 905 for framing between 0,15L from the fore end and the collision bulkhead.

Framing in 'Tween Decks and Superstructures

609 In 'tween decks marked B (*see* notes to Table 13) between 0,12L from the after end and 0,2L from the fore end and in detached superstructures, frames may be fitted two frame spaces apart provided the main frame spacing does not exceed 760 mm. and the ratio of that spacing in millimetres to the minimum thickness of the 'tween deck side plating does not exceed 55 in ships 90 metres or less in length and 45 in ships 150 metres or more in length, with intermediate values in proportion.

610 At each end of a bridge four frames are to extend from the 'tween deck below to the bridge deck.

611 'Tween deck and superstructure frames are to be efficiently scarphed to the main frames below or effectively attached to the deck, except in the poop where the lower ends of the intermediate frames (if fitted) need not be attached.

Cruiser Sterns

612 Cruiser sterns are to have frames of size required in peaks, and are to be additionally stiffened by web frames where required. The floor plates are to be of a reasonable depth, and are to be associated with a middle line girder.

General

613 Floors in fore and after peaks are to have a thickness 1 mm. greater than required for floors in a double bottom. In after peaks the floors are to extend well above the stern tube, or, if this is impracticable, cross-tie plates flanged on both edges are to be fitted above the stern tube. Rivets connecting floors and cross-tie plates to the frames are to be spaced not more than five diameters apart. (*See* D 908.)

614 In boiler rooms and permanent coal bunkers the thickness of the framing is to be increased 1,5 mm. beyond that derived from the Tables.

615 Where the depth of the framing is reduced adequate stiffness is to be maintained.

616 The breadth of the shell flange of the frames is to be suitable for the diameter of rivet used.

Cross-references

617 For framing in deep water ballast tanks, in oil fuel bunkers and in machinery spaces, *see* D 19, D 20 and D 22.

Section 7 (*See* Note on page 29)

SHELL PLATING

Scantlings

701 Scantlings of flat plate keel and of garboard strakes with a bar keel are given in Table 14, notes 1 and 2.

702 The thicknesses of bottom and side shell plating are to be determined from Table 14 and associated notes. The depth D for use in the Table is defined in D 203.

703 In way of an effective superstructure the thickness of bottom and side plating may be based on D measured to superstructure deck, but clear of the superstructure D is to be taken to the uppermost continuous deck. The thicker plating is to be suitably extended within the ends of the superstructure to ensure continuity of strength. (*See* 710.)

704 The scantlings of the sheerstrake are to be in accordance with Table 18 and D 1101.

Openings in Shell Plating

705 All openings in the shell plating for cargo doors, inlets, or other purposes, are to have well rounded corners, and arrangements are to be made to maintain the strength in way of the openings; the plating is to be reinforced in way of hawse pipes.

706 Where side scuttles or other openings are cut in the sheerstrake, removing more than 20 per cent of the Rule sectional area of the unpierced plate, compensation is to be provided.

Shift of Riveted Butts

707 The butts of shell plates and those of sheerstrake and stringer plates are to be arranged to give as good a shift as practicable; in adjoining strakes butts are to be generally at least two frame spaces apart.

The butts of the sheerstrake are to be at least two frame spaces from those of adjacent deck stringer plates.

Welded Construction

708 In ships having transverse framing, if the seams and butts of the bottom shell plating are flush welded and the floor angles are riveted to the bottom shell then the thickness of the bottom plating is to be increased for 0,4L amidships by 5 per cent above the requirements of Table 14 and associated notes.

If the seams and butts of bottom shell plating are flush welded and the floors are welded to the shell, the thickness of the bottom plating is to be increased for 0,4L amidships by 15 per cent above the requirements of Table 14 and associated notes.

In addition to the provisions of D 503, the following stiffening is to be fitted to the bottom shell for 0,4L amidships with either system of construction:—

Beam not exceeding 15,25 metres.	Two longitudinal stiffeners p. & s.
Beam above 15,25 metres and not exceeding 16,75 metres.	Four longitudinal stiffeners p. & s.
Beam above 16,75 metres and not exceeding 19,5 metres.	Three longitudinal stiffeners, and one intercostal side girder p. & s.

Special consideration will be given to ships having greater beam.

The stiffeners are to be 150 × 90 × 11,5 ordinary angle toe welded to the plating and connected at their ends. The intercostal side girders are to be of scantlings given in Table 6.

This stiffening, in which the engine girder system may be incorporated, is to be suitably scarphed to the stiffening forward required by D 801 and D 805, and is to be tapered gradually at the aft end.

For quality of steel, *see* D 3104.

Wood Belting

709 Wood belting and fenders are not to be through bolted to the shell plating.

Continuity of Strength

710 Continuity of strength is to be maintained at the break of superstructures as required by D 1206 and D 1305 to D 1308.

Section 8 (*See* Note on page 29)

STRENGTHENING OF BOTTOM FORWARD

Extent

801 The bottom structure is to be strengthened between 0,05L and 0,25L from the fore end. A sketch showing sections in way of the bottom forward is to be submitted.

Shell Plating

802 The thickness of the three strakes next to the keel plate, or, in small ships, two strakes provided these cover the flat of bottom, is to be that given in Table 14, col. 8, increased by 30 per cent where the length of the ship does not exceed 135 metres and 15 per cent where the length is 200 metres; the increase at intermediate lengths to be in proportion. In ships with machinery aft not exceeding 90 metres in length the increase is to be 40 per cent and the keel plate is not to be less in thickness than the adjacent bottom plating.

The midship thickness of the above strakes is to be carried forward to the increased plating.

If the floors are welded directly to the bottom plating the latter is to be increased in thickness.

Double Bottoms

803 Floors and intercostal girders are not to be flanged.

804 Plate floors are to be fitted at every frame and are to be connected to the bottom plating by double angles, or equivalent connections, extending from margin to margin, or, in single bottom ships, to lower turn of bilge.

805 The intercostal side girders are not to be more than 2,15 metres apart, the plating between them being supported by additional half-height intercostal girders carried as far forward as practicable.

806 Where longitudinal framing is adopted in the double bottom the arrangements are to include plate floors fitted on alternate frames between 0,05L and 0,25L from the fore end and the spacing of longitudinal framing is to be in accordance with the requirements of D 606.

Single Bottoms

807 The reversed frames are to be doubled and additional intercostal girders are to be fitted; in other respects the requirements for double bottoms are to be carried out where they apply.

Riveting

808 The rivets in both flanges of the frame angles are to be spaced $5\frac{1}{2}$ diameters apart. The diameter of rivets in butts and seams of bottom plating is to be appropriate to the increased thickness of the plating, and the seams are to be double riveted.

Section 9 (*See* Note on page 29)

ARRANGEMENTS TO RESIST PANTING

Extent

901 The structure is to be strengthened to resist panting for 0,15L from the fore end and abaft the after peak bulkhead.

Forward of the Collision Bulkhead

902 Tiers of beams spaced 1,85 metres apart are to be fitted to alternate frames below the lowest deck and are to have the scantlings given in Table 15.

903 Stringer plates of the scantlings given in Table 16 are to be fitted at each tier of beams. The stringer plates are to have double attachments to the shell plating. Alternatively, stringer plates of Table scantlings may be fitted inside the frames without attachment to the shell plating provided the stringer plate is stiffened on both edges, and the thickness of the shell plating is 10 per cent greater than the thickness given in Table 14, col. 7, where the length of the ship does not exceed 45 metres, and 25 per cent where the length is 105 metres or above; the increase at intermediate lengths is to be in proportion.

904 Frames to which a beam is not fitted are to be attached to the stringer plate by brackets, having the same thickness as the beam knees and a depth of one-half the breadth of the stringer plate.

Abaft the Collision Bulkhead

905 The strength of the side frames below the lowest deck for the distance defined in 901 is to be increased above that derived from Table 12 by 20 per cent where D is less than 10,7 metres and 5 per cent where D is 15,25 metres or greater, intermediate values by interpolation, the value of "h" for use in the Tables being the maximum between 0,15L from the fore end and the collision bulkhead, measured as defined in D 205.

906 The strength of the attachment of the frames to the tank side brackets, of the tank side brackets to the margin plates and gussets, and of the gussets to the margin plate is to be increased by 20 per cent above the requirements of Table 11. The connection of the floors to the margin plate is to be the same as the connection of the tank side brackets to the margin plate, and, where riveted, the connecting angles inside the tank are to be on the same side of the floor as the outside connections, to take through rivets.

907 Side stringers of the scantlings given in Table 16 are to be fitted in line with those forward of the collision bulkhead and are to extend aft for the distance defined in 901; they are to be attached to the shell by single riveted angles.

The side stringers may be omitted provided the shell plating is increased by the percentage given in 903.

Abaft the After Peak Bulkhead

908 The structure is to be efficiently stiffened by deep floors and tiers of beams in association with stringers as required in the fore peak (Tables 15 and 16) except that these may be spaced 2,45 metres apart. In twin screw ships the frames abaft the propeller brackets and up to the lowest deck are to be attached to the shell plating by two rows of rivets or equivalent connections. (*See* D 613.)

Special arrangements may be required in single screw ships of high speed.

If, on account of the ship's form, the unsupported length of the frames exceeds 2,45 metres, additional stiffening may be required.

For details of welding in after peak tank structure *see* D 3110.

Deep 'Tween Decks

909 If necessary, in ships with deep 'tween decks additional intercostal side stringers supported by web frames are to be fitted at the forward and after ends. The stringers may be omitted provided the thickness of the shell plating is suitably increased.

Section 10

STRENGTHENING FOR NAVIGATION IN ICE

General

1001 The vertical extent of ice strengthening is related to Light and Load waterlines which are to be determined as follows:—

Light waterline: is the lowest waterline, taking account of trim, at any point along the length of the ship corresponding to either of the following conditions:—

(*a*) The lightest load condition in which the ship may be expected to be at sea in ice conditions,

(*b*) The ballast condition.

Load waterline: is that corresponding to the winter load line.

The position of maximum breadth on the winter load waterline is to be indicated on the plans.

CLASS 1*

Framing

1002 The frame spacing is not to exceed 610 mm. between the forward perpendicular and 0,25L forward of midships and 800 mm. over the remainder of the length to the after peak bulkhead.

1003 Intermediate frames are to be fitted over the full length of the ship. The strength of these frames is to be the same as that of the adjacent rule main or 'tween deck frames.

In the panting region and in deep tanks, the modulus of the intermediate frames may be determined from the modulus of the main frames before the increases required by D 905 and D 1909 are applied.

The intermediate frames are to extend from the upper deck, or from the second deck provided this is at least 760 mm. above the load waterline, to below the level of the top of floors or to a point just above the tank top where this runs horizontally to the ship's side, and need not be connected at their ends. Where the second deck is above the load waterline but less than 760 mm. above, the intermediate frames may terminate at a stringer situated not less than 1200 mm. above the load waterline.

In the fore and aft peaks the main and intermediate frames are to have the same modulus as the rule midship frame without corrections, or a modulus equal to twice that of the normal peak frames, whichever is the greater.

Where the frames terminate at the 2nd deck, and long or broad hatchways are fitted in this deck, the plating in

way of the hatchways is to be suitably strengthened by fitting web frames or strong beams to give adequate support to the framing.

Frames are not to be scalloped, except at the seams in the shell plating.

Shell Plating

1004 From the forward perpendicular aft for a length equal to the distance from the forward perpendicular to the point where the load waterline reaches its greatest breadth plus 10 per cent of that distance, and extending vertically from 610 mm. below the light waterline to 760 mm. above the load waterline, the thickness of the shell plating is to be 80 per cent greater than Table 14, col. 6, corrected for frame spacing only at the rate of 0,5 mm. for every 50 mm. of difference from the spacing given in Table 14, col. 4 or, where appropriate, that required by D 605 or D 606.

1005 From this position to 0,25L aft of amidships and over the same vertical extent, the thickness of shell plating is to be 40 per cent greater than Table 14, col. 6, corrected for frame spacing only.

If the parallel middle portion on the load waterline extends further aft than 0,25L aft of amidships, the 40 per cent increase in shell plating thickness is to extend over this parallel middle portion.

1006 For the remainder of the length and over the same vertical extent, the thickness of shell plating is to be 25 per cent greater than Table 14, col. 6, corrected for frame spacing only.

1007 The side and bottom shell plating below this belt from the stem to a position five frame spaces abaft the point where the bow profile departs from the level keel line is to be 80 per cent greater than Table 14, col. 6.

1008 The increased thickness need not exceed 32 mm., but is not to be less than 14 mm. Changes in thickness are to take place gradually.

1009 When the s.h.p. exceeds 2,26 (L × B), the shell plating for the longitudinal extent given in 1004 shall be increased by a further 1 mm. for each 500 s.h.p. excess over the above figure, but need not exceed 32 mm. (The s.h.p. is to be indicated on the plan on which the shell plating is approved).

Stringers

1010 Forward of the collision bulkhead the tiers of beams and stringers required by D 9 are to be spaced not more than 1300 mm. apart.

Abaft the collision bulkhead the stringer next below the load waterline is to be extended over the full length of the ship, unless a deck is situated not more than 1200 mm. below the load waterline, and the main and intermediate frames are to be attached thereto.

In single deck ships a stringer is to be arranged in the vicinity of the load waterline.

The stringers immediately above and below this stringer are also to be extended over the full length of the ship, but may be intercostal and of the same scantlings as the frames in way.

Rudder and Steering Arrangements

1011 The diameters of the rudder head and pintles are to be increased by 30 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 50 per cent above that required by Table 46. The gudgeons, remaining rudder items and couplings are to be based on the increased rudder head or pintle and the steering gear is to be suitably protected against, or designed to withstand, the increased loading.

In welded double plate rudders, the horizontal and vertical webs are not to be welded direct to the side plates, but are to be attached to flat bars or equivalent arrangements made to avoid hard points.

The rudder head is to be protected by a suitable stern.

A centreline vertical skeg should be fitted abaft the rudder.

Sternframe

1012 The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 30 per cent above the rule requirements.

Stem

1013 The bow should be of a form specially designed for navigation in ice, i.e. an ice-breaker type bow should be fitted.

A solid stem of forged, rolled, or cast steel is to be fitted up to 760 mm. above the load waterline and the sectional area is to be 30 per cent greater than rule requirements.

Above this position, a plate stem may be fitted and the thickness of plates at 760 mm. above the load waterline is to be 80 per cent greater than Table 14, col. 6, without corrections, but need not exceed 25,5 mm. The thickness

may be tapered to that of the normal plate stem (*see* D 307) at the upper deck. Plates which require to be furnaced are to have these thicknesses when finished.

The connections of the shell plating to the stem are to be flush.

Below the load waterline the stem should be reinforced by a centreline web, and supported transversely by floors or horizontal webs spaced not more than 685 mm. apart.

1014 Attention is to be paid to the minimum thickness of frames, stringers and other stiffening members. In general, this should not be less than one-half that of the attached hull plating.

Cargo Doors

1015 Cargo doors, where the sills are below the load waterline, must not be fitted in the ship's side.

Cross-reference

1016 For machinery requirements *see* H 8.

CLASS 1

Framing

1017 Intermediate frames are to be fitted over the full length of the ship. The strength of these frames is to be the same as that of the adjacent rule main or 'tween deck frames, unless stringers are fitted in accordance with 1021 when the intermediate frames may be 75 per cent of the adjacent rule frames. In the panting region and in deep tanks, the modulus of the intermediate frames may be determined from the modulus of the main frames before the increases required by D 905 and D 1909 are applied.

The intermediate frames are to extend from 915 mm. below the light waterline to 760 mm. above the load waterline. They are to be connected at their ends to the adjacent frames by a horizontal member having the same scantlings as these frames, or equivalent arrangements are to be provided. Alternatively, they are to be carried down to within 250 mm. of the margin plate or, where the ship has no double bottom, to a point below the top of the floors. If the frames are so extended they need not be attached at the lower end.

In the fore and aft peaks the main and intermediate frames are to have the same modulus as the rule midship frame without corrections, or a modulus equal to twice that of the normal peak frames, whichever is the greater.

Frames are not to be scalloped, except at the seams in the shell plating.

Where stringers are not fitted, brackets are to be arranged to prevent the frames from tripping.

Shell Plating

1018 From the forward perpendicular aft for a length equal to the distance from the forward perpendicular to the point where the load waterline reaches its greatest breadth plus 10 per cent of that distance, and extending vertically from 610 mm. below the light waterline to 760 mm. above the load waterline, the thickness of the shell plating is to be 50 per cent greater than Table 14, col. 6, corrected for frame spacing at the rate of 0,5 mm. for every 50 mm. of difference from the spacing given in Table 14, col. 4, or, where appropriate, that required by D 605 or D 606.

1019 For the remainder of the length over the vertical extent given in 1018 the thickness is to be 25 per cent greater than Table 14, col. 6, corrected for frame spacing only. The change of thickness is to take place gradually.

1020 The increased thickness need not exceed 25,5 mm., but is to be not less than 12,5 mm.

Stringers

1021 The following requirements apply only when the intermediate frames are made 75 per cent of the adjacent rule main or 'tween deck frames (*see* 1017).

Abaft the collision bulkhead stringers of the scantlings given in Table 16 are to be fitted 1,85 metres apart for the longitudinal extent given in 1018.

The stringer next below the load waterline is to be extended over the full length of the ship unless a deck is situated not more than 610 mm. below the load waterline.

1022 Attention is to be paid to the minimum thickness of frames, stringers and other stiffening members. In general, this should be not less than one-half that of the attached hull plating.

Rudder and Steering Arrangements

1023 The diameters of the rudder head and pintles are to be increased by 25 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 50 per cent above that required by Table 46. The gudgeons, remaining rudder items and coupling are to be based on the increased rudder head or pintle and the steering gear is to be suitably protected against, or designed to withstand, the increased loading.

In welded double plate rudders, the horizontal and vertical webs are not to be welded direct to the side plates, but are to be attached to flat bars or equivalent arrangements made to avoid hard points.

The rudder head is to be protected by a suitable cruiser stern or other equivalent arrangements.

Sternframe

1024 The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 25 per cent above the rule requirements.

Stem

1025 The sectional area of a solid stem bar is to be 25 per cent greater than rule requirements.

The connections of the shell plating to the stem bar are to be flush.

Where a plate stem is fitted, the thickness of the plates below a position 760 mm. above the load waterline is to be 65 per cent greater than Table 14, col. 6, without corrections, but need not exceed 25,5 mm. The thickness may be tapered to that of the normal plate stem (*see* D 307) at the upper deck. Plates which require to be furnaced are to have these thicknesses when finished.

Below the load waterline, plate stems should be reinforced by a centreline web and the spacing of horizontal webs is not to exceed 915 mm.

Cross-reference

1026 For machinery requirements *see* H 8.

CLASS 2

Framing

1027 Intermediate frames are to be fitted for the longitudinal extent given in 1018. The strength of these frames is to be the same as that of the adjacent rule main or 'tween deck frames, unless stringers are fitted in accordance with 1029 when intermediate frames may be 75 per cent of the adjacent rule frames. In the panting region and in deep tanks, the modulus of the intermediate frames is to be determined from the modulus of the main frames before the increases required by D 905 and D 1909 are applied.

The intermediate frames are to extend from 915 mm. below the light waterline to 760 mm. above the load waterline. They are to be connected at their ends to the adjacent frames by a horizontal member having the same scantlings as these frames, or equivalent arrangements are to be provided. Alternatively, they are to be carried down to within 250 mm. of the margin plate or, where the ship has no double bottom, to a point below the top of the floors. If the frames are so extended they need not be attached at the lower end.

In the fore and aft peaks the main and intermediate frames are to have the same modulus as the rule midship frame without corrections, or a modulus equal to twice that of the normal peak frames, whichever is the greater.

Frames are not to be scalloped, except at the seams in the shell plating, over the area where the shell plating is increased by 50 per cent (*see* 1028).

Shell Plating

1028 For the longitudinal and vertical extent given in 1018 the thickness of the shell plating is to be 50 per cent greater than Table 14, col. 6, corrected for frame spacing at the rate of 0,5 mm. for every 50 mm. of difference from the spacing given in Table 14, col. 4, or, where appropriate, that required by D 605 or D 606.

For the remainder of the length over the same vertical extent the thickness is to be 15 per cent greater than Table 14, col. 6, corrected for frame spacing only. The change of thickness is to take place gradually.

The increased thickness need not exceed 25,5 mm., but is to be not less than 12,5 mm.

Stringers

1029 The following requirements apply only when the intermediate frames are made 75 per cent of the adjacent rule main or 'tween deck frames (*see* 1027).

Abaft the collision bulkhead stringers of the scantlings given in Table 16 are to be fitted 1,85 metres apart for the longitudinal extent given in 1018.

Rudder and Steering Arrangements

1030 The diameters of the rudder head and pintles are to be increased by 12,5 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 25 per cent above that required by Table 46. The gudgeons, remaining rudder items and coupling are to be based on the increased rudder head or pintle and the steering gear is to be suitably protected against, or designed to withstand, the increased loading.

In welded double plate rudders, the horizontal and vertical webs are not to be welded direct to the side plates, but are to be attached to flat bars or equivalent arrangements made to avoid hard points.

Sternframe

1031 The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 15 per cent above rule requirements.

Stem

1032 The sectional area of a solid stem bar is to be 15 per cent greater than rule requirements.

The connections of the shell plating to the stem bar are to be flush.

Where a plate stem is fitted the thickness of the plates below a position 760 mm. above the load waterline is to be 65 per cent greater than Table 14, col. 6, without corrections, but need not exceed 25,5 mm. The thickness may be tapered to that of the normal plate stem (*see* D 307) at the upper deck. Plates which require to be furnaced are to have these thicknesses when finished. The spacing of horizontal webs below the load waterline is not to exceed 915 mm.

Cross-reference

1033 For machinery requirements *see* H 8.

CLASS 3

Framing

1034 For the longitudinal extent given in 1018, intermediate frames are to be fitted abaft the forward perpendicular. They are to extend from 915 mm. below the light waterline to 760 mm. above the load waterline, and need not be connected at their ends.

The intermediate frames forward of the collision bulkhead should have a modulus equal to 50 per cent of the rule peak frames, and those aft of the collision bulkhead should have a modulus equal to 75 per cent of the rule peak frames, but in 'tween decks need not exceed the adjacent frame.

Frames are not to be scalloped, except at the seams in the shell plating, over the area where the shell plating is increased by 25 per cent (*see* 1035).

Shell Plating

1035 For the vertical extent given in 1018 and from the forward perpendicular to the point where the load waterline reaches its greatest breadth the thickness of the shell plating is to be 25 per cent greater than Table 14, col. 6, corrected for frame spacing at the rate of 0,5 mm. for every 50 mm. of difference from the spacing given in Table 14, col. 4, or, where appropriate, that required by D 605 or D 606.

The increased thickness need not exceed 25,5 mm. but is to be not less than 12,5 mm.

For the remainder of the length, the thickness is to be normal rule. The change of thickness is to take place gradually.

Stringers

1036 Abaft the collision bulkhead stringers of the scantlings given in Table 16 are to be fitted 1,85 metres apart for the longitudinal extent given in 1018. The stringers may be omitted provided the intermediate frames are made 80 per cent of the strength of the adjacent main frames, but if the span of the intermediate frames exceeds 6,1 metres, suitable arrangements are to be made to prevent tripping.

Rudder and Steering Arrangements

1037 The diameters of the rudder head and pintles are to be increased by 7,5 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 10 per cent above that required by Table 46. The gudgeons, remaining rudder items and coupling are to be based on the increased rudder head or pintle and the steering gear is to be suitably protected against, or designed to withstand, the increased loading.

In welded double plate rudders, the horizontal and vertical webs are not to be welded direct to the side plates, but are to be attached to flat bars or equivalent arrangements made to avoid hard points.

Sternframe

1038 The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 7,5 per cent above rule requirements.

Stem

1039 The sectional area of a solid stem is to be 10 per cent greater than rule requirements.

The connections of the shell plating to the stem bar are to be flush.

Where a plate stem is fitted, the thickness of the plates below a position 760 mm. above the load waterline is to be 50 per cent greater than Table 14, col. 6, without corrections, but need not exceed 25,5 mm. The thickness may be tapered to that of the normal plate stem (*see* D 307) at the upper deck. Plates which require to be furnaced are to have these thicknesses when finished. The spacing of horizontal webs below the load waterline is not to exceed 915 mm.

Cross-reference

1040 For machinery requirements *see* H 8.

Section 11 (*See* Note on page 29)

DECKS

Plated Decks

1101 Strength deck and sheerstrake scantlings are to be determined from Table 18 and associated notes. The depth D for use in the Table is defined in D 203. Strength deck requirements are tabulated for ships having one, two or three decks. If there is more than one deck the sectional

Type of Truck	Total Weight of Truck and Load Metric Tons											
	3	4	5	6	7	8	9	10	11	12	13	14
	Minimum Deck Thickness (irrespective of beam or longitudinal spacing) Millimetres											
Two Wheels at Fork End	7,5	9,0	10,0	11,0	12,0	12,5	13,5	14,0	15,0	15,5	16,0	16,5
Four Wheels in pairs at Fork End ...	6,5	7,5	8,0	9,0	9,5	10,5	11,0	11,5	12,0	12,5	13,0	13,5

area of the strength deck given in Table 18 is that required when the scantlings of the lower decks are in accordance with Table 20.

1102 Scantlings for effective superstructures, as defined in D 206, are also to be determined from Table 18, the depth D being measured to the superstructure deck. (*See* Table 18, note 8.)

1103 Minimum thicknesses of strength decks and lower decks are given in Tables 18 and 20 respectively.

For quality of steel, *see* D 3104, D 3105 and D 3106.

1104 Platform decks for which no credit is taken in determining the scantlings of the strength deck (*see* 1101) are to have the scantlings given in Table 20, col. 8.

Decks with Stringer and Tie Plates

1105 The scantlings of stringers and tie plates fitted under a wood deck are to be determined from Table 18, note 9, and Table 20, note 5.

Tie plates are to be fitted at each side of the hatchways and are to be continuous; where these form the upper members of girders supported by widely spaced pillars they are to be suitably increased. Cross ties are to be arranged at the ends of hatchways and other openings. The decks are to be plated over abreast machinery openings, the plating being tapered into the stringer plates beyond the openings.

Stringer Angles

1106 The butts of strength deck stringer angles are to be efficiently welded or strapped and if the angle is cut in way of scuppers compensation is to be provided.

Concentration of Loading

1107 Additional strengthening to the decks may be required where there is indication of concentration of loading.

Fork Lift Trucks

1108 Where Owners desire to make provision for the use of fork lift trucks it is recommended that the deck thickness should not be less than that given above.

Where Owners desire to use fork lift trucks on insulated decks or tank tops special consideration will be given to the permissible loading in association with the insulation arrangements and the plating thickness.

Continuity of Strength

1109 Continuity of strength is to be maintained at the ends of large openings in the strength deck and the deck below by means of corner doubling plates or equivalent arrangements, and associated, if necessary, with intercostal girders at the strength deck. Special attention is to be given to workmanship at these parts.

For welded construction, *see* D 3108.

Wood Sheathing and Decks

1110 The material is to be of good quality, well seasoned and free from sapwood. The thickness is to be not less than 65 mm. for pine or 50 mm. for teak.

Thwartship planks are to be laid at the ends of hatchways, deckhouses and similar boundaries.

The vertical flange of coaming or foundation angles is to extend 12,5 mm. above the wood deck. Gutterway angles or welded flats are to be not less than 7,5 mm. in thickness.

The planking is to be efficiently fitted. Fastenings are to be not less than 12,5 mm. in diameter, sunk below the surface of the planking and covered with turned dowels, the whole being thoroughly bedded in white lead or other suitable composition.

Bolts are to be galvanised; welded studs used instead of bolts are to be coated with suitable composition before the planking is laid.

All decks are to be caulked and payed.

Deck Compositions

1111 If an approved composition is laid as a substitute for wood sheathing the steel deck is to be caulked, made watertight and coated with a suitable material in order to prevent corrosive action between the steel and the composition. The composition is to be effectively secured to the deck. (*See* F 807 and F 1003).

Caulking and Water Testing

1112 All plated decks are to be caulked unless sheathed with a properly caulked wood deck. The spaces between frames at lower decks are to be effectively closed by cement or other means.

Weather decks and gutterways are to be hose tested on completion.

Deck Loading

1113 The Rule scantlings of decks are appropriate to the following cargo loads:—

(*a*) Upper Deck—A height of 1,25 metres and a stowage rate of 1,39 cubic metres per 1000 kg.

On the hatch the height is to be taken as 1,5 metres and 1,25 metres for Table 43A or Table 43B hatches respectively. (*See also* Note 7 of Table 43).

(*b*) Second and Lower Decks (*including the Hatch Covers*)—A height equal to the mean height of the part of the 'tween deck under consideration and a stowage rate of 1,39 cubic metres per 1000 kg.

(*c*) Decks Forming the Crown of a Tank—The greater of the values derived either in accordance with (*b*) or by taking a head equal to one half the height of the air pipe above the crown of the tank and a stowage rate of 0,975 cubic metres per 1000 kg.

Ships to which a timber load line is assigned are required to be specially strengthened (*see* D 1408 and D 1526) and Owners are referred to the Load Line Convention regarding the permissible height of timber deck cargo. Other ships may carry a timber deck cargo equivalent to a load of 2,29 metres at 1,39 cubic metres per 1000 kg.

Section 12 (*See* Note on page 29)

DETACHED SUPERSTRUCTURES

Forecastles

1201 All seagoing ships are to have forecastles except where the load draught is less than 0,7D. Where the omission of the forecastle may be necessary, increased sheer forward is to be provided as may be required by the Committee.

Short Superstructures

1202 The scantlings of poops and forecastles, and of bridges not exceeding 0,15L in length, are to be determined from Table 21 and associated notes.

All seams and butts may be single riveted.

Long Bridges

1203 A long bridge is an effective superstructure as defined in D 206, and the scantlings are to be determined from Table 18 and associated notes. (*See* D 703 and D 1102.)

Second and third deck scantlings may be reduced in way of the superstructure. (*See* Table 18, note 8.)

1204 The riveting of butts and seams of deck plating, sheerstrake and side plating is to be as required by Table 52 B & C, but the side plating and sheerstrake seams are not to be less than double riveted for four frame spaces at the ends of the superstructure.

1205 Transverse strength is to be ensured by fitting web frames or partial bulkheads in the bridge if large deckhouses are constructed above.

Strengthening at Ends of Superstructures

1206 The thickness of the upper deck sheerstrake is to be increased by 50 per cent and the thickness of the stringer plate by 25 per cent at the ends of long bridges. Similar strengthening is to be fitted at the ends of poops or forecastles within 0,5L amidships.

At the ends of short bridges these increases are to be 30 per cent and 10 per cent respectively.

In way of a long bridge the upper deck sheerstrake, stringer plate and deck plating as fitted in the wells are to extend into the bridge for a distance equal to about one-third the breadth of the ship.

The bridge side strakes, which are to be increased 25 per cent in thickness at the ends of the superstructure, are to be tapered as far as practicable into the bulwark plating or upper deck sheerstrake; the plating is to be efficiently stiffened at its upper edge and supported by web plates not more than 1,5 metres from the end bulkhead.

Bulkheads at Ends of Superstructures

1207 The bulkheads at the ends of poops, bridges, and forecastles are to have the scantlings and arrangements given in Table 22 and associated notes.

Deckhouses

1208 All deckhouses are to be of sufficient strength and the scantlings of the ends, sides and of the top beams are to be in accordance with the requirements of Table 23 and associated notes. Beams and stiffeners should, as far as possible, be fitted in line with the main framing.

1209 Where the length of single or two-tier deckhouses exceeds 0,15L, the sectional area of the top plating is to be derived from Table 23 and associated notes. In all ships above 91,5 metres in length the exposed decks over passenger accommodation are to be completely plated.

1210 The sides and ends of the deckhouses are to be supported by partial bulkheads or web frames, spaced about 9,15 metres apart, and web frames are to be fitted, if practicable, at the sides of large openings.

Arrangements are to be made to minimise the effect of discontinuities in the deckhouse structure. All openings cut in the sides should be substantially framed and have the corners well rounded; continuous coamings are to be fitted below and above doors and similar openings.

Particular attention is to be given to the structure at the corners and ends of long deckhouses. Adequate support under the ends of the houses is to be provided in the form of web frames at ships' sides and diaphragms or pillars near the centre line in conjunction with reinforced deck beams. The corners of the deckhouses should be connected to the deck by double riveted or equivalent connections, which, if incorporating welding, will be specially considered.

The deckhouse sides are to be additionally stiffened in way of boats and the top strengthened in way of the davits.

1211 Partial bulkheads or web frames are to be fitted in the 'tween decks below deckhouses and, where practicable, in continuation of watertight bulkheads below.

Cross-reference

1212 For exposed casings protecting machinery openings, *see* D 22 and Table 23, note 11.

For scantlings of deck plating inside long deckhouses *see* Table 18, note 2 (*d*).

For aluminium superstructures, *see* F 812.

Section 13

RAISED QUARTER DECKS

Scantlings in way of the Raised Quarter Deck

1301 The scantlings of shell, sheerstrake, stringer and deck plating are to be based on the depth D measured to the raised quarter deck.

1302 The scantlings of side frames are to be based on the depth D measured to the upper deck with h measured to the raised quarter deck.

1303 The scantlings of beams are to be determined using the depth D measured to the raised quarter deck.

Break Bulkhead

1304 The front or break bulkhead of the raised quarter deck is to have the thickness of plating required for bridge front bulkheads and is to be sufficiently stiffened.

Strengthening at Break

1305 The stringer plates of the upper or bridge deck and the raised quarter deck are to overlap for three or four frame spaces at either side of the break bulkhead according to the size and proportions of the ship.

1306 Similarly in ships exceeding 67,1 metres in length the deck plating is to overlap for two or three spaces and the stringers are to extend for two or three spaces beyond the plating.

1307 Sufficient diaphragm plates, of the thickness of the break bulkhead, are to be fitted between the overlapped decks and connected to them and to the break bulkhead by double angles; the diaphragms are to be stiffened on their after edges and elsewhere if necessary.

1308 The upper deck sheerstrake is to be increased in thickness by 40 per cent and extended for a reasonable distance abaft the break. The raised quarter deck sheerstrake is also to be increased in thickness by 30 per cent when connected to a long bridge and is to be extended into the bridge.

Section 14 (*See* Note on page 29)

BEAMS AND DECK LONGITUDINALS

Scantlings

1401 The scantlings of deck beams at weather, cargo and accommodation decks are to be determined from Tables 24 and 25 and associated notes.

1402 The scantlings of deck longitudinals are to be determined from Tables 26 and 27 and associated notes.

General

1403 Beams are to be fitted at every frame.

1404 Where hatch side coamings are more than 457 mm. from the deck girder the overhanging beams are to be reinforced, or the coamings are to be made sufficiently strong to act as girders to carry the ends of the beams and the load on the hatchway.

1405 Beams or longitudinals at the crown of deep tanks, peak tanks and oil fuel tanks are to satisfy the requirements of Tables 24, 25, 26 or 27 and associated notes but are not to be less in strength than the standard required for the stiffeners of the boundary bulkheads to those tanks. (*See* D 1901 and D 2004.)

1406 Where holes are punched in the face flange of channel or similar beams the modulus of the beams may require to be increased.

1407 Weather decks are to be suitably cambered.

Timber Deck Cargoes

1408 Where timber load lines are to be assigned the scantlings of deck beams at weather decks are to be in accordance with Table 24, note 6.

Beam Knees and Brackets of Deck Longitudinals

1409 The scantlings of beam knees and brackets of deck longitudinals together with their riveted attachments are to be determined from Table 28.

1410 Where intermediate frames in the 'tween decks are omitted the beam knees are to be attached to the shell plates by angles having the same thickness as the knees.

1411 In ships having more than three tiers of beams and where large areas of deck are arranged for accommodation, or where particular conditions of loading are contemplated, the requirements for beam knees will be specially considered.

1412 The riveted attachment of half beams to hatch side coamings and casings is given in Table 52 H.

Cross-references

1413 For strong hatch end beams and deck transverses, *see* D 1512 to D 1515.

For strengthening in machinery spaces, *see* D 2207.

Section 15 (*See* Note on page 29)

DECK GIRDERS AND PILLARS

General

1501 Deck beams are to be supported by longitudinal deck girders in association with pillars or strong hatch end beams.

Deck longitudinals are to be supported between bulkheads by transverses pillared as necessary.

For the forward 0,075L of forecastle and weather decks, longitudinal girders are not to be spaced more than 3,66 metres apart, and transverses not more than 2,44 metres apart. Girders are to have intercostal plates attached to the deck and are not to consist of angle runners.

Pillars in the 'tween decks and holds are to be in the same vertical line, as far as practicable.

The scantlings are to be determined from Tables 29, 30 and 31 and associated notes.

Special Loads

1502 Where a girder is subject to concentrated loads, such as pillars out of line, the scantlings are to be suitably increased and the pillars which support the girder are to be strengthened to bear the portion of the concentrated load which they carry.

1503 Where cargoes such as chilled meat are suspended from a deck which may be simultaneously loaded above, the scantlings of the girders are to be increased as required by Table 29, note 1 (*f*).

1504 Additional attachments may be required to meet particular local stresses.

Longitudinal Deck Girders

1505 Girders are to be connected to the deck by angles of the same thickness as the web plate. If the span is greater than 9,15 metres in association with a normal height of 'tween deck, the deck connection is to be doubled for two beam spaces at each end.

1506 Girders of unsymmetrical section are to be supported by tripping brackets at alternate beams; if the section is symmetrical the brackets may be four frame spaces apart. Where the unsupported width of the girder flanges is 150 mm. or greater the tripping brackets are to be connected to the face bar or flange. Where symmetrical sections are fitted tripping brackets are to be fitted on both sides. Intermediate beams are to be connected to the girders by lugs having the same thickness as the web plate and extending to the toe of the face bar or to the flange.

The thickness of deck plating in way of the girder is to be increased where necessary to provide an effective upper flange of the girder.

1507 Girders are to be attached to the bulkhead by flanged brackets of the same thickness as the girder. The distance of the toe of the bracket below the deck is given in Table 29 and the horizontal arm is to be the same as the depth below the girder. The connections of the bracket to the girder and the bulkhead are to be double riveted.

1508 Continuity is to be efficiently maintained over the heads of pillars, and the butts of longitudinal material in the girders are to be efficiently strapped or welded.

Hatch Coamings

1509 At lower decks side coamings acting as girders and not forming part of a continuous girder are to be extended for at least two frame spaces beyond the hatch end beams by short girders below the deck.

1510 At weather decks deep hatch coamings which are intended to act as girders are to be extended beyond the hatchway ends in the form of brackets, the coamings below the deck being effectively connected to the hatch end beams. Where extension above the deck is not practicable the coaming below the deck is to be extended by short girders for at least two frame spaces beyond the hatch end beams.

For welded construction, *see* D 3108.

1511 At the corners of all hatchways supported by hatch end beams horizontal gusset plates are to be fitted connecting the side coamings to the hatch end beams, and the vertical connections are to be double riveted or equivalent.

Strong Hatch End Beams

1512 Strong hatch end beams are to be supported at the centre line and attached to the side frames by brackets equivalent to the requirements of Table 29, and the frames are also to be strengthened if considered necessary.

1513 The hatch end beams are to be connected to the deck plating by angles of the same thickness as the web plate and sufficient tripping brackets are to be fitted.

Deck Transverses

1514 Transverses supporting deck longitudinals are to be attached to the frames by brackets equivalent to the requirements of Table 29, and tripping brackets are to be fitted as required. The transverses are to be connected to the deck by angles of the same thickness as the web plates.

1515 Longitudinals are to be attached to the transverses by lugs having the same thickness as the web plates and extending to the toe of the face bar.

Pillars

1516 Effective arrangements are to be made to distribute the loads at the heads and heels of all pillars.

1517 Solid pillars may be attached to continuous runners, having scantlings given in Table 30, fitted under the deck beams. The runners are to be attached to each beam and to the bulkheads by angle lugs having two rivets in each flange. The heads and heels of the pillars are to have a bearing fit. At watertight and oiltight surfaces the heels are to be riveted to double angles or T bars or directly welded.

1518 Tubular pillars are to be attached at their heads to suitable capital plates supported by brackets, flanged where necessary, in order to transmit the load effectively.

Doubling plates are to be fitted to the inner bottom under the heels of tubular pillars, and to decks under pillars of large diameter. The pillars are to have a bearing fit and are to be attached to the capital and doubling plates by riveted angle rings or by continuous welding.

1519 At the heads and heels of pillars built of rolled sections the load is to be well distributed by means of longitudinal and transverse brackets.

1520 In double bottoms under widely spaced pillars the connections of the floors to the intercostal girders and of the floors and girders to the inner bottom are to be suitably increased. Where pillars are not directly above the intersection of plate floors and intercostal girders, partial floors and intercostals are to be fitted as necessary to support the pillars. Manholes are not to be cut in the floors and girders below the heels of pillars.

Where longitudinal framing is adopted in the double bottom, equivalent stiffening under the heels of pillars is to be provided.

1521 In ships carrying refrigerated cargoes and carrying oil fuel in the double bottom, the connections of the hold pillars to the inner bottom, including the doubling plates, are to be welded. (*See* D 2022.)

1522 Where the heels of pillars are carried on a tunnel suitable arrangements are to be made to support the load.

1523 Where pillars are fitted under watertight flats the end attachments are to be sufficient to withstand the load due to water pressure.

1524 Additional pillars are to be fitted below deckhouses, windlasses, winches, capstans and elsewhere where considered necessary. The structure in way of the boat davits is to be strengthened.

Machinery Spaces

1525 Arrangements for supporting the structure in machinery spaces will be specially considered.

Timber Deck Cargoes

1526 Where timber load lines are to be assigned the scantlings of weather deck longitudinal girders, strong hatch end beams, deck transverses and pillars are to be in accordance with Table 29, note 6 and Table 31, note 6. Particular attention is to be paid to the end connections of girders and hatch end beams. (*See also* D 1408.)

Cross-references

1527 For centre line and bunker bulkheads supporting decks, *see* D 18.

For riveting, *see* Tables 31 and 52 H.

Section 16 (*See* Note on page 29)

WATERTIGHT BULKHEADS

Number and Disposition of Transverse Bulkheads

1601 All ships are to have a collision bulkhead, situated not less than 0,05L from the fore end of the load waterline, an after peak bulkhead enclosing the stern tubes in a watertight compartment and a bulkhead at each end of the machinery space.

When a coal cross bunker is situated at the forward end of the boiler space, its after bulkhead may be of non-watertight construction as required by D 18, provided the forward bulkhead complies with the requirements of this section for watertight bulkheads.

If this compartment is to be used for cargo, the after bulkhead is to be welded or riveted and caulked as required by this Section, and all openings are to be blanked off and made watertight. The requirements of D 29 are to be complied with, and bilge suctions and sounding pipes fitted as required for a separate hold compartment.

1602 In ships exceeding 67,1 metres in length, additional watertight bulkheads are to be fitted so that the total number of bulkheads is in accordance with the following Table.

Length L		Total number of bulkheads	
Above	Not exceeding	Machinery amidships	Machinery° aft
metres	metres		
—	67,1	4	3
67,1	86,9	4	4
86,9	102,1	5	5
102,1	112,8	6	5
112,8	123,4	6	6
123,4	143,3	7	6
143,3	164,6	8	7
164,6	185,9	9	8

° After peak bulkhead forming the after boundary of the machinery space.

1603 The bulkheads in the holds should be spaced at reasonably uniform intervals. Where this is departed from and the length of a hold is unusually great, the tranverse strength of the ship is to be maintained.

1604 The Committee will be prepared to consider proposals from owners to dispense with one or more of these bulkheads if they interfere with the requirements of a special trade, subject to suitable structural compensation.

Height of Bulkheads

1605 The collision bulkhead is to extend to the uppermost continuous deck.

1606 The after peak bulkhead may terminate at the first deck above the load waterline provided this deck is made watertight to the stern or to a watertight transom floor.

1607 The remaining bulkheads are to extend to the uppermost continuous deck except where the draught is not greater than that permitted with a superstructure extending for the full length of the ship above the second deck, when the bulkheads may terminate at that deck provided it lies above the load waterline.

In passenger ships of restricted draught the height of the bulkheads will be specially considered.

Bulkhead Plating

1608 The thickness of bulkhead plating is to be in accordance with Table 32 and associated notes.

1609 The lowest strake is to be at least 900 mm. deep measured from the inner bottom, or from the keel if there is no double bottom; where an inner bottom terminates on a bulkhead the top of the lowest strake of the bulkhead is

to be at least 300 mm. above the inner bottom. At stokehold bulkheads in coal burning ships the lowest strake is to extend at least 600 mm. above the stokehold platform.

Bulkhead Stiffeners

1610 The scantlings of vertical stiffeners having bracketed or lugged end connections are to be determined from Table 33 or 34 respectively, and associated notes. The scantlings of stiffeners which are bracketed at one end and lugged at the other may be taken as a mean between those required by Tables 33 and 34.

The scantlings for stiffeners in tugs are given in Table 35.

1611 The Tables apply to stiffeners spaced 610 mm. apart at collision bulkheads and 760 mm. apart at other watertight bulkheads not forming boundaries of tanks. Scantlings are to be corrected as required by the notes for departures from Table spacing.

1612 Where bulkhead stiffeners are cut in way of watertight doors in the lower part of a bulkhead the opening is to be suitably framed, and a tapered web plate, stiffened on its edge, is to be fitted on each side of the door from the base of the bulkhead to well above the opening.

Where stiffeners are not cut but the spacing between the stiffeners is increased on account of watertight doors, as in 'tween deck bulkheads, the stiffeners at the sides of the doorways are to be increased in depth and strength so that the efficiency is at least equal to that of the unpierced bulkhead, without taking the stiffness of the door frame into consideration.

1613 Bulkheads are to be suitably strengthened if necessary at the ends of deck girders and where subjected to concentrated loads.

End Attachments of Stiffeners

1614 End brackets for stiffeners derived from Table 33 are to have dimensions, measured from the heel of the boundary angle to the toes of the bracket, equal to two and a half times the depth of the stiffener. The thickness of the brackets and the number of rivets required are given in Table 36.

The bracket or its connecting angle at the lower end of each stiffener is to extend to the floor adjacent to the bulkhead.

At each deck level which forms the top of a system of stiffeners plating is to be provided of a character which will ensure rigidity, and the attachments of the upper brackets on the hold stiffeners to this plating are to extend over a beam space.

Where the inner bottom is framed longitudinally the stiffeners of the bulkhead should be arranged, if practicable, over the longitudinals.

1615 End lugs for stiffeners derived from Table 34 are to be of the same thickness as the boundary angles and are to be riveted as required by Table 36.

Boundary Connections

1616 Angles connecting bulkheads to shell, inner bottom and deck plating are to be 2,5 mm. thicker than the Table thickness of the bulkhead plating to which they are attached.

Watertight Recesses and Flats

1617 Watertight recesses in bulkheads are to be so framed and stiffened as to provide strength and stiffness equivalent to the requirements for watertight bulkheads.

1618 Horizontal plating is to be 1 mm. thicker than required by Table 32 for watertight bulkheads at corresponding levels. The strength and stiffness of beams are to be equivalent to the requirements of Table 33 if cut and bracketed or continuous.

The thickness of plating and scantlings of beams are not to be less than required by D 11 and D 14.

Longitudinal Bulkheads

1619 Watertight longitudinal bulkheads are to be equal in strength and stiffness to the requirements for transverse bulkheads.

Chain Lockers

1620 Chain lockers fitted abaft the collision bulkhead are to be caulked and the space is to be efficiently drained.

Riveting

1621 Requirements for riveting are given in Table 52 H.

Welded Stiffeners

1622 The scantlings of welded stiffeners will be considered in accordance with note 3 to Tables 33 to 36.

Watertight Doors

1623 Watertight doors are to be efficiently constructed and fitted, tried under working conditions and hose tested in place. (*See* 1627.)

Provision should be made to ensure that coal will not impede the satisfactory operation of bunker doors.

1624 Watertight doors are to be capable of being quickly closed from an accessible position above the bulkhead deck, and are to have an index at the operating position showing whether the door is open or closed. Hand gear is to have an all-round motion. The lead of shafting is to be as direct as possible and the screw is to work in a gunmetal nut.

1625 Hinged watertight doors of approved pattern may be fitted in 'tween decks in approved positions. The hinges of these doors are to be fitted with gunmetal pins.

Caulking and Testing

1626 Watertight bulkheads, including recesses and flats, are to be caulked and hose tested on completion. At watertight flats the side frames if continuous are to be suitably collared, alternatively they may be cut and bracketed or otherwise effectively connected to the flat.

Peak bulkheads not forming boundaries of tanks are to be tested by filling the peaks with water to the level of the load waterline.

Passenger Ships

1627 In passenger ships, the number and construction of the watertight bulkheads and watertight doors will be specially considered. Each watertight door shall be tested by water pressure to a head up to the bulkhead deck. The test may be carried out either before or after the door is fitted. (*See* F 801 and F 805).

Cross-references

1628 For deep tanks, peak tanks and oil fuel bunkers, *see* D 19 and D 20.

For watertight tunnels, *see* D 17.

For machinery casings in 'tween decks, *see* D 2214.

Section 17

WATERTIGHT TUNNELS

Tunnels

1701 Where machinery is amidships the shafting is to be enclosed in a watertight tunnel large enough to permit of proper examination and repair of the shafting. A watertight door is to be provided at the forward end of the tunnel. Pipe tunnels are to have dimensions adequate for reasonable access.

Plating

1702 The thickness of plating on flat sides and curved tops of tunnels is to be determined from Table 37 and associated notes.

If the top of the tunnel is flat the plating is to be as required by D 1618 for horizontal flats of watertight bulkheads.

1703 Under hatchways the top plating is to be increased by 2,5 mm., unless covered with wood not less than 50 mm. in thickness which is to be secured without through fastenings in the plating.

Stiffeners and End Attachments

1704 The scantlings of stiffeners are to be determined from Table 38 and associated notes.

For flat tunnel tops the scantlings of stiffeners are not to be less than required by D 1618 for flats of watertight bulkheads.

The stiffeners are to overlap and be connected to the tunnel base angle. Angle stiffeners 150 mm. in depth and all bulb angle stiffeners are to be attached to the inner bottom by lugs riveted as required by Table 36. Where welded construction is adopted equivalent arrangements are to be made.

Boundary Angles

1705 The thickness of all boundary angles is to be 2,5 mm. greater than the Table thickness of curved top plating given in Table 37.

Recesses

1706 The scantlings of plating and stiffeners for thrust and other recesses are to be determined as required by D 1617 and D 1618 for watertight bulkheads.

Tunnels in Deep Tanks

1707 When tunnels and recesses form boundaries of deep tanks the requirements of D 19 or D 20 are also to be complied with.

Local Strengthening

1708 Additional strengthening is to be fitted under the heels of pillars, hatch end supports or masts stepped on the tunnel. The strength of bulkheads in way of watertight doors is to be maintained as required by D 1612.

Ventilators

1709 Tunnel ventilators are to have scantlings suitable for the pressure to which they may be subjected and are to be made watertight.

Riveting, Caulking and Testing

1710 Riveting and caulking are to be as required by D 1621 and D 1626 for watertight bulkheads.

Tunnels are to be hose tested on completion.

Section 18 (*See* Note on page 29)

NON-WATERTIGHT BULKHEADS

Centre Line Bulkheads

1801 The thickness of bulkhead plating in ships exceeding 45 metres in length is to be 7,5 mm. in holds and 6,5 mm. in 'tween decks.

1802 Riveted connections of bulkheads to the decks and inner bottom are to be by single angles 9 mm. in thickness, but the attachments to the inner bottom are to be double riveted for two frame spaces at the ends of the hatchways; welded connections are to be of equivalent strength.

1803 The scantlings of stiffeners are to be determined from Table 39 and associated notes. The stiffeners may be spaced two frame spaces apart provided the frame spacing does not exceed 760 mm.

1804 Hold stiffeners are to be attached to the inner bottom by double riveted lugs or welded at their lower ends. Stiffeners at the ends of hatchways, both in holds and 'tween decks, are to have flanged brackets at top and bottom, or equivalent arrangements. Deck beams are to be connected to the stiffeners or plating of the bulkhead.

Coal Bunker Bulkheads

1805 The thickness of plating is to be as required by 1801, but the thickness of the lowest strake is to be 9 mm.; this strake is to extend at least 600 mm. above the stokehold platform. Boundary angles are to be 9 mm. in thickness at the top and sides and 10 mm. at the bottom.

1806 The scantlings of stiffeners of longitudinal bulkheads which support the deck are to be as required by 1803.

1807 The scantlings of stiffeners of transverse bulkheads and of longitudinal bulkheads not supporting the deck are to be as required by Table 39, note 4.

1808 At sloping bunker casings the scantlings of stiffeners are to be suitably increased or the stiffeners are to be additionally supported by angle stays from the deck beams.

Cross-references

1809 For non-watertight bulkheads at after end of cross bunkers, *see* D 1601.

For passenger ships, *see* F 801.

Section 19 (*See* Note on page 29)

DEEP TANKS AND PEAK TANKS

Bulkheads

1901 The scantlings of plating and stiffeners of boundary bulkheads are to be determined from Tables 32 and 40 respectively, and associated notes. The plating is not to be less in thickness than 7,5 mm. in ships exceeding 45 metres in length. Stiffeners are to have bracketed attachments as required by D 1614.

1902 Boundary angles are to be 2,5 mm. thicker than the Table thickness of the bulkhead plating to which they are attached.

1903 The maximum head to which the tank will be subjected is to be shown on the plans submitted for approval.

1904 For tanks which exceed 9 metres in length the scantlings and arrangements will be specially considered.

Decks

1905 The thickness of plating of a deck forming the crown of a tank is to be 1 mm. greater than that which would be required by Table 32 for plating at the same depth, corrected, if necessary, for spacing, but is to be not less than 8 mm. with beams or longitudinals spaced 610 mm. apart and 10 mm. where the spacing is 915 mm., with proportionate thickness for intermediate spacing; the plating is also to satisfy the requirements of D 11.

1906 Beams are to be equivalent in strength to the stiffeners of boundary bulkheads, but are also to satisfy the requirements of D 14.

1907 Beams in deep tanks are to be supported by quarter girders, the scantlings of which are to be determined from Table 41 and associated notes but are not to be less than would be required by D 15.

1908 Pillars supporting the deck girders are to satisfy the requirements of D 1516 to D 1524.

Side Frames

1909 The modulus of side frames in deep tanks is to be increased by 15 per cent beyond the requirements of D 6.

Where the frame spacing exceeds the frame spacing in Table 12 by 75 mm. or more, special consideration will be given to this framing.

Tunnels and Recesses

1910 The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally, are to be equivalent to the requirements for boundary bulkheads.

Centre Line Bulkheads

1911 Where a complete centre line division is fitted in deep tanks the arrangements are to be as required by D 2016 and D 2017.

Ventilators

1912 Ventilators from deep tanks passing through a 'tween deck are to be strong enough to withstand the pressure to which they may be subjected and they are to be made watertight.

Riveted Connections

1913 Riveted connections are to be in accordance with the requirements of Table 52 H.

Testing

1914 Tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected, but not less than 2,5 metres above the crown of the tanks where the depth D (as defined in D 203) exceeds 5 metres, reduced to 1 metre where D is 3 metres or less.

When a preservative coating is to be applied to the internal structure of a tank, the water testing may take place after the application of the preservative, provided the structure is carefully examined to ensure that all welding and structural stiffening is completed prior to the application of the coating and any riveted shell seams are tested with a high pressure hose test on the berth before coating. The hose test of the riveted seams may be carried out from the outside to avoid wetting the tank structure. As an alternative to hose testing, a leak test as described in D 5202 would be accepted.

The cause of any discoloration or disturbance of the coating is to be ascertained and any deficiencies repaired.

General

1915 When boundary bulkheads of tanks form part of the watertight subdivision of the ship the requirements of D 16 are also to be satisfied.

1916 Tanks intended to carry oil fuel or liquid cargoes are to comply with the requirements of D 20 or D 21.

Cross-references

1917 For air and sounding pipes, *see* D 24.

For pumping and piping arrangements, *see* Chapter E.

Section 20 (*See* Note on page 29)

DEEP TANKS AND DOUBLE BOTTOM TANKS CARRYING OIL FUEL FOR SHIP'S USE

Flash Point

2001 The following requirements apply to the construction of compartments for the carriage of oil fuel for ship's use.

2002 The close test flash point (as determined by a standard type of flash point apparatus) is to be above 65,5° C.

Boundary Bulkheads

2003 The thickness of plating is to be determined from Table 32 and associated notes; the plating is not to be less than 7,5 mm. in thickness in ships exceeding 45 metres in length.

2004 The scantlings of stiffeners are to be determined from Table 40 and associated notes. The ends of the stiffeners are to be attached by brackets in accordance with D 1614. The stiffeners are to be supported, if necessary, by horizontal girders as required by 2006 to 2009.

2005 For tanks which exceed 9 metres in length the scantlings and arrangements will be specially considered.

Horizontal Girders

2006 Bulkhead stiffeners and side frames may be supported by horizontal girders having scantlings determined from Table 41 and associated notes.

2007 If girders are fitted, they are to form a continuous line of support on bulkheads and ship's side. They are to be connected at their ends by flanged brackets, having the same thickness as the web plate of the thicker girder and a length of arm, measured from the point of the bracket to the edge of the girder, equal to the width of the wider girder. If the bracket terminates on a bulkhead the length of the arms is to be equal to the width of the girder. All girders and brackets are to be double riveted or to have equivalent welded connections and the ends of the brackets are to be adequately supported.

2008 Riveted connections of girder plates to the bulkheads or shell plating are to be double for about twice the width of the girder at each end and may be single elsewhere.

2009 The girders are to be supported by tripping brackets at the toes of the end brackets and elsewhere at every third stiffener or frame. Stiffeners or frames intermediate between these brackets are to be effectively connected to the girders.

2010 For tanks which exceed 9 metres in length the scantlings and arrangements will be specially considered.

Side Frames

2011 The modulus of the side frames is to be increased by 15 per cent beyond the requirements of D 6 unless horizontal side girders are fitted.

2012 If horizontal side girders are fitted the scantlings of the frames are to be determined as required by D 6, modified as given below, and the scantlings of the frame for the full depth of the tank are to be the maximum of the section moduli derived by the following three methods:—

1. h measured to lowest horizontal girder (minimum value 2,5 metres) and the resulting modulus increased by 15 per cent.
2. h measured from a single girder to the deck forming the crown of the tank or between girders when two or more girders are fitted.
3. h measured from uppermost girder (when two or more girders are fitted) to the deck forming the crown of the tank and the resulting modulus reduced by 15 per cent.

Decks

2013 The scantlings of decks forming the crowns of oil fuel tanks are to comply with the requirements for deep tanks given in D 1905 to D 1908.

2014 Where a steel deck abuts on an oil bunker bulkhead the deck plating is to be attached to the bulkhead either by double angles, single riveted, by a T bar, or by an equivalent welded connection. If the deck acts as a girder supporting the bulkhead stiffeners the panel of deck plating adjoining the bulkhead may require to be stiffened for this purpose.

Tunnels and Recesses

2015 The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally, are to be equivalent to the requirements for boundary bulkheads.

Centre Line Bulkheads

2016 Deep tanks which extend from side to side of the ship are to have a centre line bulkhead and quarter girders.

2017 Centre line bulkheads may be intact or perforated as desired. If intact, the scantlings and arrangements are to be as required for boundary bulkheads by 2003 to 2005.

If perforated, the modulus of the stiffeners may be 50 per cent of that required for boundary bulkheads by D 19, using H measured to the crown of the tank. The stiffeners are to be bracketed at top and bottom. The area of perforations is to be not less than 5 per cent nor more than 10 per cent of the total area of the bulkhead.

When brackets from horizontal girders on the boundary bulkheads abut on the centre line bulkhead a light intercostal stringer is to be fitted at that level for the full length of the tank, or equivalent arrangements are to be provided.

Ventilators

2018 Ventilators from deep tanks, passing through a 'tween deck, are to be strong enough to withstand the pressure to which they may be subjected and they are to be made oiltight.

Watertight Subdivision

2019 When the bulkheads of oil fuel bunkers form part of the watertight subdivision of the ship, they are also to comply with the requirements of D 16.

Double Bottom Tanks

2020 Holes are not to be cut in the centre girder except in the forward and after tanks, and elsewhere where tanks are narrow due to subdivision. The centre girder need not be caulked or tested.

2021 The inner bottom plating in cargo holds where there is no ceiling is to be not less in thickness than 8,5 mm. when the spacing of frames or longitudinals is 610 mm., and 10 mm. when the spacing is 760 mm., with proportionate thicknesses for intermediate spacing.

Seams and end laps of inner bottom plating in the engine and boiler spaces, and in the holds where ceiling is not fitted over the whole inner bottom, are to be at least double riveted.

Special Requirements for Refrigerated Ships

2022 Where the hold above a double bottom tank carrying oil fuel is used for refrigerated cargo the tank side brackets and floor plates are to be attached to the margin plate by T bars, or by welding, and gussets are to be welded to the margin plate. The connections of hold pillars, including heel doubling plates, also of the floors and

intercostal plates under the pillars to the inner bottom, are to be welded. The attachments of manhole covers are not to pass through the inner bottom plating.

2023 For the requirements for protection of oiltight bulkheads, decks and inner bottom in way of refrigerated holds, *see* E 345 and E 346.

Protection and Drainage

2024 Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

2025 Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

2026 Where a bulkhead including its boundary connections is wholly welded, the requirements of 2025 may be dispensed with, except that a gutterway is to be fitted in the boiler room.

2027 Ceiling on the inner bottom, if fitted, is to be laid on battens not less than 12 mm. in thickness. Battens are to be so laid as to permit the drainage of oil to the bilges or wells.

2028 Drip trays or gutterways with suitable draining arrangements are to be provided for all tanks which do not form part of the hull structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded, when the drip trays need only be fitted over the boilers.

2029 If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

Riveted Connections

2030 Riveted connections are to be in accordance with the requirements of Table 52 H.

Testing

2031 All oil tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected but not less than 2,5 metres above the crown of the tank where the depth D (as defined in D 203) exceeds 5 metres, reduced to 1 metre where D is 3 metres or less. The attachment of fittings to oiltight surfaces should be completed before the tanks are tested.

Workmanship

2032 The workmanship throughout is to be of the highest character and is to be submitted to close inspection. (*See* D 31 and D 32.)

Cross-reference

2033 For air and sounding pipes and the arrangements and requirements for the use of oil fuel, *see* Chapter E.

Section 21 (*See* Note on page 29)

DEEP TANKS AND PEAK TANKS CARRYING OIL AS CARGO

Oil Fuel

2101 Oil fuel having a flash point above 65,5° C. may be carried as cargo in deep tanks or peak tanks providing the scantlings and arrangements of the tanks are in accordance with the requirements of D 20 for oil fuel bunkers, except that the riveting may be as required for deep tanks by Table 52 H and the centre line bulkhead need not be fitted; if, however, the tanks are intended to be partially filled only, the requirements of D 20 are to be complied with in all respects.

2102 When these requirements have been carried out a notation will be made in the Register Book as follows: "Deep tanks and (or) peak tanks—oil F.P. above 150° F."

Vegetable and Similar Oils

2103 Vegetable oil, or similar oils, may be carried in deep or peak tanks constructed in accordance with the requirements of D 19 for ballast tanks, with the addition of a centre line bulkhead as required by D 2016 and D 2017, provided that the ventilation, drainage and control generally are as required for oil fuel bunkers.

2104 Tanks are to be designed and constructed with a view to their being cleaned with reasonable facility.

2105 Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water by a cofferdam.

2106 When these requirements have been complied with a notation will be made in the Register Book as follows: "Deep tanks and (or) peak tanks—vegetable oil."

2107 Vegetable oil may also be carried in tanks complying with the requirements of 2101 and if desired the notation may be as follows: "Deep tanks and (or) peak tanks—oil F.P. above 150° F. or vegetable oil."

2108 Where tanks are intended for other liquid cargoes of a special nature the scantlings and arrangements will be considered in relation to the density and nature of the cargo and an appropriate notation will be made in the Register Book.

Loading Certificates

2109 When a loading certificate is requested, before a cargo of oil is loaded the tank should be tested under pressure and examined for cleanness to ensure that it is in a proper condition to receive the oil cargo.

In special circumstances the Committee will be prepared, with the consent of all interested parties, to consider alternative arrangements in respect of the testing of these tanks.

Cross-references

2110 For protection of oiltight bulkheads and decks in way of refrigerated holds, *see* E 345 and E 346.

Section 22

MACHINERY SPACES

Engine Seatings

2201 Built-up engine seatings are to be of ample scantlings and efficiently supported by brackets both longitudinally and transversely. The transverse brackets should be fitted over the floors and, as far as practicable, the longitudinal girders in the bottom are to be under those in the seating.

2202 If engines are bolted directly to the inner bottom the thickness of the plating under the engines is to be suitably increased.

The plating under the foremost shaft tunnel bearing is also to be increased in thickness and is to be scarphed in to the heavy plating under the engine bedplate.

2203 In ships having a single bottom in the engine space, the floors are to be increased in depth (*see* D 403) and the engines are to be seated on plating of substantial thickness.

2204 Additional full depth fore and aft girders are to be fitted under the engines and thrust block seatings. (*See* D 416, D 504 and D 505.)

2205 If engines are of relatively high power the strength of the structure and attachments of the seating are to be increased, special consideration being given to the power and type of engines and the relation of height of the engines to the width of the bedplate; particulars are to be submitted.

Boiler Bearers

2206 Boiler bearers are to be of substantial construction and efficiently supported by brackets. (*See* D 407 and D 507.)

Additional Strengthening in Machinery Space

2207 Additional transverse strengthening is to be provided by means of web frames and strong beams, with suitable pillaring or other arrangements.

Clearance between Bulkheads and Boiler

2208 Bunker and hold bulkheads are to be kept well clear of boilers and uptakes, and sufficient space is to be allowed all round boilers for proper access.

2209 Decks, or the tops of recesses, are to be not less than 1,25 metres clear of the top of the boiler. Uptakes and flat surfaces of boilers are to be not less than 460 mm., and the cylindrical shells of boilers not less than 230 mm., from coal bunker and hold bulkheads.

Protection of Decks under Donkey Boilers

2210 Decks under donkey boilers are to be increased 2,5 mm. in thickness and protected under coal-fired boilers by not less than 50 mm. of firebrick or cement. These requirements are to extend to any part of the deck on to which fires from the donkey boiler may be drawn.

Exposed Casings Protecting Machinery Openings

2211 Engine and boiler openings on weather decks are to be protected by casings of adequate height having scantlings determined from Table 23 and associated notes. The tops of casings are to be suitably plated and stiffened.

2212 The deck openings should not be larger than necessary and suitable cross tie arrangements are to be provided.

2213 On the uppermost continuous deck of ships in which the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and on raised quarter decks, the doors in exposed casings are to be of steel. All doors are to be strongly constructed and capable of being closed and secured from both sides.

The sills of exposed doorways on the uppermost continuous deck, where the draught is as defined above, are to be 610 mm. in height above the upper surface of the deck; the sills of exposed doorways on raised quarter decks are to be 457 mm. and those on other superstructure decks including those extending for the full length of the ship 380 mm. in height.

Protected Casings

2214 The plating is to be not less than 6,5 mm. in cargo spaces and 5 mm. in accommodation spaces in superstructures; stiffeners are to be $75\times65\times6,5$ mm. angles spaced 760 mm. apart. Where trunked casings form boundaries of coal bunkers they are to comply with the requirements of D 1805 to D 1808.

Skylights and Gratings

2215 Engine room skylights are to be substantially constructed and are to be securely connected to the coamings. Gratings over stokehold openings are to be protected by hinged plate covers, which are to be watertight if the level of the openings is less than 610 mm. above the top of the hatch coamings required by D 2301. (*See* also F 336.)

Means of Escape

2216 Two means of escape, one of which may be a watertight door, shall be provided from each engine room, shaft tunnel and boiler room. Where no watertight door is available, the two means of escape shall be formed by two sets of steel ladders as widely separated as possible leading to doors in the casing similarly separated and from which access is provided to the lifeboat embarkation deck. In the case of ships less than 2000 tons gross tonnage, this requirement may be dispensed with, due regard being paid to the width and disposition of the casing.

Communications

2217 Two means of communication are to be fitted between the bridge and the engine room. One means shall be an engine room telegraph.

Aluminium Alloy

2218 When aluminium alloy is used in the construction of the boundaries of the machinery space or in the casings or pillars, suitable insulation is to be fitted so that the structure remains effective in the presence of intense heat. The extent of the insulation is to be governed by the fire risk on either side of the boundary.

Cross-references

2219 For scantlings of single bottoms in machinery space, *see* D 417.

For scantlings of double bottoms in machinery space, *see* D 533 and D 534.

For frames in boiler room, *see* D 614.

For passenger ships, *see* F 807, F 812 and F 814.

Section 23

HATCHWAYS AND DECK OPENINGS

Height of Coamings

2301 The minimum height of steel coamings above the upper surface of decks is to be as follows:—

On the weather portions of the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... ... 610 mm.

On the weather portions of superstructure decks, including superstructures extending for the full length of the ship, for the forward 0,25L ... ... 610 mm.
for the remainder and on raised quarter decks 457 mm.

On decks inside superstructures where the openings in the end bulkheads have no means of closing... 457 mm.

On decks inside superstructures where the openings in the end bulkheads are closed by strong hinged wood doors, wood shifting boards fitted in channels or portable plates secured by hook bolts ... ... 229 mm.

2302 Hatchways on other decks and in positions not detailed in 2301 are to be suitably framed.

Construction of Coamings

2303 At hatchways exposed to the weather the thickness of the side and end coaming plates is to be 11 mm. where the length L is 61 metres or greater and 9 mm. where L does not exceed 30 metres, with intermediate values obtained by interpolation. Coamings are to be stiffened on their upper edges by a substantial moulding. At hatchways below the uppermost continuous deck or within an intact superstructure the coamings are to be not less than 10 mm. in thickness.

2304 Angles connecting the coamings to the deck and the corner angles connecting the side and end coamings are to be of the same thickness as the coaming plates. Coaming angles are to extend 10 mm. above the wood deck.

2305 Side coamings of all hatchways are to extend at least to the lower edge of the beams, which are to be attached to the coamings as required by Table 52 H.

For welded construction, *see* D 3108.

2306 Hatchway side and end coamings which are 610 mm. or more in height are to be stiffened by a horizontal bulb angle, or equivalent, fitted near the upper edge of the coaming; in ships 76 metres or more in length the bulb angles are to be not less than 180 mm. in depth. Additional support is to be afforded by fitting brackets or stays from the bulb angle to the deck at intervals of not more than 3 metres.

2307 The scantlings and arrangements of coamings more than 915 mm. in height and of coamings acting as girders will be specially considered. (*See* D 1404 and D 1509 to D 1513.)

2308 Coamings are to be made watertight above the deck and coaming angles are to be suitably turned or the coamings welded.

2309 Extension brackets or rails arranged approximately in line with the hatch side coamings and intended for stowage of steel covers are not to be welded to a deckhouse, masthouse, or to each other, unless they form part of the longitudinal strength members.

Hatchway Beams and Carriers

2310 Scantlings of hatchway beams are to be determined from Table 43 and associated notes.

2311 Web plate beams are to be stiffened at their upper and lower edges by double angles or welded face plates, but when bulb plates are fitted this stiffening is required at the upper edge only. The upper angles or face plates are to extend to the extreme ends of the beams.

2312 The ends of the web plates are to be flushed up on each side by doubling plates of the same thickness as the mounting angles and at least 180 mm. wide. In welded hatchway beams, equivalent arrangements for stiffening the ends of the web plates are to be adopted.

2313 At beams which carry the ends of wood hatch covers the web plate is to extend well above the top of the upper angles or face plate of the hatch beams. The bearing surface for hatch covers is to be not less than 65 mm. (*See* 2320.)

2314 Hatchway beams are to be supported at their ends by carriers, sockets or other suitable arrangements, having a minimum bearing surface of 75 mm. Carriers formed of angles are to be not less than 12,5 mm. thick and one angle is to be extended down to the level of the deck. If the carriers are of a form which will not permit of extension to the deck level the coaming plate is to be increased in thickness by 12½ per cent, or equivalent strengthening provided.

2315 The bottoms of all carriers are to be of solid construction.

2316 Sliding hatchway beams are to be provided with an efficient device for locking them when in their correct fore and aft positions.

Hatch Covers

2317 Hatch covers are to be fitted to the hatchways of all decks, except that at hatchways on decks as defined in 2302 the hatch covers may be dispensed with if desired by the Owners and specially approved by the Committee when a suitable notation will be entered in the Register Book.

2318 The finished thickness of wood hatch covers at hatchways on weather decks, and in 'tween decks of normal height, is to be 60 mm. for an unsupported span of 1,52 metres, and 83 mm. for 1,98 metres; the thicknesses for intermediate spans are to be in proportion.

When the 'tween deck height in cargo spaces exceeds 2,6 metres the thickness of the covers is to be increased at the rate of 5 per cent per 0,3 metre excess in 'tween deck height.

2319 The ends of all wood hatch covers are to be protected by encircling galvanised steel bands, about 65 mm. wide and 3 mm. thick, efficiently secured.

2320 Hatch rests are to be of the same thickness as the mounting angles given in Table 43 A & B and are to provide at least 65 mm. bearing surface for the hatch covers; they are to be bevelled if required to suit the slope of the hatches.

Tarpaulins and Securing Arrangements

2321 Tarpaulins in good condition are to be provided for all hatchways requiring coamings 229 mm. or more in height; not less than two tarpaulins are to be provided for all hatchways in exposed positions.

2322 Tarpaulins are to be free from jute, thoroughly waterproofed and of ample strength. The minimum weight of the material before treatment is to be 0,65 kg. per square metre if the material is to be tarred, 0,60 kg. if to be chemically dressed or 0,55 kg. if to be dressed with black oil.

A certificate to the above effect is to be supplied by the makers of the tarpaulins.

2323 Cleats are to be fitted at all hatchways requiring tarpaulins, spaced not more than 610 mm. from centre to centre, the end cleats being arranged not more than 150 mm. from the hatchway corners. Cleats are to be of an approved pattern at least 65 mm. wide, with edges so rounded as to minimise the cutting of the wedges. The thickness should

be not less than 10 mm. for angle cleats and 11 mm. for smithed cleats which should be stiffened by pressing out the centre to form a web extending to the bottom of the palm. Drop forgings should be of equivalent strength. Cleats should be so set as to fit the taper of the wedges.

2324 Battens and wedges are to be efficient and in good condition. Wedges are to be of tough wood, generally not less than 200 mm. in length and 50 mm. in width. They should be cut on a standard taper of one in six and should be not less than 15 mm. in thickness at the point.

2325 Where coamings are required to be 610 mm. in height, steel bars or other equivalent means are to be provided for efficiently and independently securing each section of hatchway covers after the tarpaulins are battened down. Where hatchway covers extend over intermediate supports, steel bars or their equivalent are to be fitted at each end of each section of covers. At all other hatchways in exposed positions on weather decks, ring bolts or other fittings for lashings are to be provided.

Steel Hatch Covers

2326 When steel hatch covers are adopted plans and particulars of the scantlings and arrangements are to be submitted.

Built steel covers are to be suitably framed to provide sufficient strength and rigidity, and the scantlings are to be determined from the formulæ given in Table 43, note 6.

Securing cleats and cross joint wedges, together with suitable jointing material, are to be fitted to secure the tightness of the covers on hatchways for which the rule height of coamings required by 2301 is 229 mm. or more. The spacing of securing cleats is not to exceed 990 mm. where rule height of coamings is 610 mm. and 1,07 metres where the rule height of coamings is 457 mm. or 229 mm. The maximum spacing of cross joint wedges is not to exceed 1,22 metres. Suitable securing arrangements are to be fitted on other hatchways.

Steel pontoon hatch covers, that is steel covers having top and end plating with interior webs and frames, extending for the full width of the hatchway and about one quarter of the length, and not fitted with direct securing arrangements, are generally to be in accordance with the requirements of Table 43 Note 6. Where this type of cover is fitted at weather deck cargo hatchways within the forward 0,25L the strength and inertia of the covers is to be at least 20 per cent above the formulæ given in Table 43 Note 6 Type A and the thickness of plating is to be at least 30 per cent above the thickness given by the same note.

Steel hatch covers with special sealing arrangements, or insulated covers, or steel hatch covers to which the requirements of 2321 to 2325 might wholly or in part be applied, will be specially considered.

Bunker, Access and Trimming Hatchways

2327 The construction and the closing and securing arrangements of bunker, access and trimming hatchways are to comply with the requirements of 2301 to 2326 so far as applicable.

Flush Bunker Scuttles

2328 Flush bunker scuttles may be fitted on superstructure decks, including raised quarter decks.

2329 The scuttles are to be substantially constructed with screw or bayonet joints. If the scuttles are not hinged the covers are to be permanently attached by a chain.

Trunked Hatchways

2330 When hatchways are trunked through one or more 'tween decks, and hatchway beams and covers are dispensed with at the intermediate decks, the hatchway beams, coamings and covers immediately below the trunk are to be adequately strengthened; plans are to be submitted for approval.

Means of Escape

2331 In and from all crew and passenger spaces and spaces in which crew are normally employed, other than machinery spaces, stairways and ladders are to be arranged so as to provide ready means of escape to the lifeboat embarkation deck. (For means of escape from machinery spaces, *see* D 2216).

Companionways

2332 Companions on exposed decks are to be of steel effectively secured to the deck. The height of the doorway sill is to be as required for hatchway coamings in the same position.

2333 Within the forward 0,25L the doors are to be of steel and elsewhere may be of hard wood not less than 50 mm. in thickness. The doors are to be capable of being operated and secured from both sides.

Section 24

VENTILATORS, AIR PIPES AND SOUNDING PIPES

Ventilation, General

2401 Where mechanical ventilation is adopted plans showing the construction of the weather deck fittings are to be submitted for approval.

Ventilator Coamings

2402 The minimum height of ventilator coamings above the upper surface of decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... 915 mm.

On superstructure decks, including superstructures extending for the full length of the ship,
for the forward 0,25L ... ... 915 mm.
for the remainder and on raised quarter decks 760 mm.

Ventilator coamings of a greater height than 915 mm. are to be specially supported and secured.

2403 The scantlings of the coamings and their attachment, if riveted to the deck plating, are to be in accordance with the following Table.

Internal diameter of ventilator coamings		Coaming plate	Deck angle	Rivets at 4 dia. spacing centre to centre
Above	Not exceeding			
Millimetres		Millimetres	Millimetres	Dia. Millimetres
—	200	7,5	75×75×8,5	19
200	280	8	75×75×9	19
280	330	8,5	90×90×9,5	19
330	380	9	90×90×10	19
380	430	9,5	90×90×10,5	22
430		10	90×90×11	22

2404 When the deck is sheathed with wood the vertical flange of the coaming angles is to extend 10 mm. above the wood sheathing.

2405 The deck plating in way of ventilator coamings is to be efficiently stiffened between the beams or longitudinals.

Covers

2406 All ventilator coamings are to be provided with strong plugs and canvas covers, or equally efficient appliances, for closing the openings when the cowls are unshipped.

Minor Ventilators

2407 Mushroom and gooseneck ventilators are to be strongly constructed and efficiently secured to the deck plating.

Air and Sounding Pipes

2408 Air and sounding pipes are to be fitted in accordance with the requirements of Chapter E.

2409 The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... 915 mm.

On raised quarter decks ... ... 760 mm.

On superstructure decks other than raised quarter decks but including those extending for the full length of the ship ... ... 457 mm.

2410 Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

2411 Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

2412 In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

Cross-references

2413 For passenger ships, *see* F 815 to F 817.

For cargo ships, *see* F 1004.

Section 25

BULWARKS, FREEING PORTS, SCUPPERS, SANITARY DISCHARGES AND SIDE SCUTTLES

Bulwarks

2501 Plate bulwarks are to be stiffened by a strong rail section and supported by stays from the deck, spaced not more than 1,85 metres apart. Where bulwarks are cut to form a gangway or other opening, stays of increased strength are to be fitted at the ends of the openings. The plating in way of mooring pipes is to be doubled or increased in thickness.

2502 The arrangements for continuity of strength at the ends of superstructures are to be as required by D 1206. Bulwarks should not be cut for gangway or other openings near the breaks of superstructures.

2503 In welded ships, the bulwarks should be arranged to ensure their freedom from main structural stresses. (*See* D 3109.)

2504 The bulwarks of ships carrying timber deck cargoes are to be not less than 990 mm. in height and are to be additionally stiffened at the upper edge; bulwark stays are to be attached to the deck in way of beams.

Freeing Ports

2505 Where weather decks are enclosed by bulwarks ample provision is to be made for rapidly freeing the decks from large quantities of water by means of freeing ports.

2506 The area of freeing port openings at uppermost continuous decks where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and at raised quarter decks, is to be as follows.

Length of well	Area on each side	Length of well	Area on each side
Metres	Square Metres	Metres	Square Metres
4,5	0,741	16,5	1,109
6,5	0,801	18,5	1,168
8,5	0,863	20,5	1,250
10,5	0,925	22,5	1,373
12,5	0,985	24,5	1,495
14,5	1,046	26,5	1,618

On superstructures, other than raised quarter decks, but including those extending for the full length of the ship, the area of the openings is to be half the area given in the preceding Table.

In ships having deficient sheer or where there is no free passage for water across the weather deck, the freeing port area is to be suitably increased or open rails are to be fitted.

Provision is also to be made for freeing water from all open or partially open spaces in which water may be shipped and contained.

2507 The lower edges of freeing ports are to be as near to the deck as practicable and the openings are to be protected by rails spaced not more than 230 mm. apart. If hinged doors are fitted over the openings their hinges are to have brass pins; fittings for keeping the doors closed are not to be provided.

Scuppers

2508 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

2509 When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

2510 Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

2511 Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screw-down, non-return valves as required by 2510.

2512 Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

2513 Scuppers which drain overboard from spaces referred to in 2511 and 2512 and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

2514 Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

2515 Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

Sanitary Discharges

2516 Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down, automatic, non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

2517 Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in 2516 may be required.

Materials for Valves and Pipes

2518 Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality. (*See also* F 706).

Protection of Pipes and Valves

2519 In all cargo spaces or coal bunkers, scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

Side Scuttles

2520 Side scuttles and deadlights are to be of approved design and are to be made of approved material other than ordinary cast iron.

Side scuttles to spaces below the freeboard deck or to spaces within enclosed superstructures are to be fitted with efficient inside deadlights permanently attached and capable of being closed watertight.

In enclosed superstructures permanently allocated to passengers or crew portable deadlights may be provided if stowed adjacent to the scuttles, provided they are accessible at all times in service.

2521 In passenger ships, the position and construction of the side scuttles will be specially considered. (*See also* F 813.)

Section 26 (*See* Note on page 29)

RUDDERS

Materials

2601 Steel castings are to comply with the requirements of P 5.

2602 Forgings made of ingot steel are to comply with the requirements of P 6.

2603 If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

Diameter of Rudder Head and Mainpiece

2604 The diameter of the rudder head is to be determined from Table 44 and associated notes and is also to be designed in relation to the maximum astern speed.

2605 The mainpiece of rudders with cast or forged frames is to be of the same diameter at the top pintle as the rudder head and is to taper evenly to the heel, where the diameter is not to be less than 75 per cent of that of the head.

2606 If the supports of the rudder are so arranged that considerable bending stresses may occur in the mainpiece and head these are to be suitably strengthened.

Single Plate Rudders

2607 The thickness of plates and scantlings of arms of single plate rudders are to be determined from Table 45 and associated notes.

2608 Arms are to be arranged on alternate sides of the plate and are to be shrunk on to the mainpiece and keyed. In way of each arm the mainpiece is to be increased in diameter by 10 per cent; this increased diameter is to extend above and below the arm for a distance equal to the increase in diameter and beyond these points is to be gradually reduced to the normal diameter of the mainpiece over a distance of one-fifth of the diameter.

2609 The thickness of the key is to be 10 per cent of the normal diameter of the mainpiece at each arm, and the width is to be twice the thickness.

Double Plate Rudders

2610 The scantlings of cast or forged frames of double plate rudders will be determined in relation to their design. The thickness of the plates is to be derived from Table 46 and associated notes.

2611 The scantlings of rudders with plate frames will depend upon the arrangements adopted. The thicknesses of the outside plates and of the horizontal and vertical web plates are to be determined from Table 46 and associated notes. Special attention is to be given to the attachment of the pintles and rudder coupling to the body of the rudder.

2612 Horizontal and vertical webs are not to be attached to side plates by tongue welds. Slot welds are only to be used in association with flat bars on the edges of the webs.

2613 The internal surfaces of double plate rudders are to be efficiently coated and means for draining the rudder are to be provided.

Pintles

2614 The scantlings of the pintles are to be determined from Table 47 and associated notes.

2615 The distance between the top pintle and the bearing of the rudder stock should be as short as possible; where the ratio of the unsupported length to the diameter of stock is excessive the diameter of the stock may require to be increased or the length reduced by fitting an additional and accessible bearing.

2616 Where liners to pintles are fitted they are to be shrunk on to the pintles or otherwise efficiently secured.

Couplings

2617 The scantlings of couplings are to be determined from Table 48 and associated notes.

2618 The bolts are to be fitted and suitable arrangements are to be made to lock the nuts.

Riveting

2619 The diameters of rivets in rudder arms are given in Tables 45 and 46.

The rivets are to be spaced $4\frac{1}{2}$ diameters apart and the holes are to be countersunk. Where the breadth of the arm exceeds 115 mm. the riveting is to be reeled and if the breadth exceeds 180 mm. two complete rows of rivets are to be fitted, but, except at the outer ends of the arms, the rivets are not to be directly opposite to each other.

General

2620 Suitable arrangements are to be provided to prevent the rudder from lifting.

2621 When the weight of the rudder is supported by a carrier bearing attached to the rudder head the structure in way is to be adequately strengthened for that purpose. The plating under all rudder head bearings or rudder carriers is to be increased in thickness or doubled.

Cross-reference

2622 For strengthening for navigation in ice, *see* D 1011, D 1023, D 1030 and D 1037.

Section 27

STEERING GEAR

General

2701 All ships are to be provided with two independent means of steering. In passenger ships and in cargo ships of 500 gross tons and above, one of the gears is to be operated by power. All gears are to be fitted and tested under working conditions to the satisfaction of the Surveyors.

2702 The power operated main steering gear is to be capable of putting the rudder over from 35 degrees on one side to 35 degrees on the other side with the ship running ahead at maximum service speed. The time taken to put the rudder over from 35 degrees on either side to 30 degrees on the other side is not to exceed 28 seconds at maximum service speed. The gear is also to be designed in relation to the maximum astern speed.

2703 The auxiliary gear is to be of adequate strength and sufficient to steer the ship at navigable speed and is to be capable of being brought speedily into action in an emergency.

2704 In cargo ships, a power operated auxiliary gear is to be fitted where the Rule diameter of the rudder stock at the tiller, corresponding to a speed of 10 knots, is 254 mm. and above. Where main steering gear power units and their connections are fitted in duplicate and the duplicate units acting together satisfy the requirements of 2702, and each power unit separately satisfies the requirements of 2703, an auxiliary gear will not be required.

2705 In passenger ships, the auxiliary gear is to be power operated if the Rule diameter of rudder stock at the tiller exceeds 229 mm. Where main steering gear power units and their connections are fitted in duplicate and each power unit separately is capable of satisfying the requirements of 2702, an auxiliary gear will not be required.

2706 In passenger ships, where the Rule diameter of the rudder stock at the tiller exceeds 229 mm., an alternative steering position remote from the main steering position is

to be provided. The steering control systems from the main and alternative steering stations are to be arranged so that failure of either system would not result in inability to steer the ship by means of the other system.

Means are to be provided to enable orders to be transmitted from the bridge to the alternative steering station.

2707 The exact position of the rudder, if power operated, shall be indicated at the main steering station.

2708 The after steering wheel and gear in ocean-going ships are to be adequately protected or situated in such a position that protection can be dispensed with.

2709 The steering gear is to be secured to the seating by fitted bolts and suitable buttressing arrangements are to be provided.

Tillers and Quadrants

2710 The scantlings of tillers and quadrants are to be as given in Tables 49 and 50. Tillers and quadrants are to be shrunk on or bolted to the rudder head, in addition to being secured by a key of suitable dimensions. The keyways are to have rounded ends. The thickness of quadrant plates is to be 1 per cent of the radius given in the Table. The area of the arms at ends may be one-third of the area given in Table 49. Arms of loose quadrants not keyed to the rudder head may be of these reduced dimensions throughout their length, and the depth of the boss may be reduced by 10 per cent.

Rod and Chain Gears

2711 Steering rods and chains are to have the diameters required by Table 49 for the radius of quadrant given therein. Shackles, shackle pins, links and other connections are to be suitable for the size of chain.

2712 All steering chains are to be subjected to the breaking and proof tests for short link chains given in P 13. These tests are to be carried out at a proving establishment recognised by the Committee and the certificates are to be produced.

2713 The leads of the steering chains are to be as direct as possible and sharp bends are to be avoided. The diameters of leading block sheaves, measured at the centre of the chain, are to be not less than sixteen times the diameter of the steering chains; the pins of the sheaves are to have not less than twice the diameter of the chains.

2714 A set of spares is to be provided consisting of one complete spring buffer and one extra spring, two tested chains each equal to the longest length in the gear, two Warwick screws, four shackles, four connecting links and four rod pins.

In ocean-going ships, the speed of which is 12 knots and above, one buffer spring, one Warwick screw and one length of chain may be dispensed with.

In ships engaged on short sea routes which have either a main gear which is hand operated at sea or an auxiliary gear, independent of the rods and chains, which can be effectively operated at sea, the spare gear may be confined to sufficient shackles or split links to enable repair of the gear to be readily effected in the event of its breakdown at sea. In all other ships engaged on short sea routes, the spare gear is to be as required for ships the speed of which is 12 knots and above.

Springs

2715 Springs, buffers or equivalent arrangements are to be fitted to all main steering gears.

Locking or Brake Gear

2716 An efficient locking or brake arrangement is to be fitted to all gears to keep the rudder steady when necessary.

In bow rudders where a vertical locking pin is operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

Rudder Stops

2717 Stops for the rudder are to be provided and strongly secured to the deck in way of the tiller or quadrant tiller. Stops on the steering engine are to be arranged at a smaller angle of helm than those for the rudder.

Section 28

MASTS AND RIGGING

2801 The scantlings of steel masts and derrick posts intended to support derrick booms of 15 tonnes S.W.L. and under are to be determined from the greatest stresses expected to arise when the cargo gear is correctly used. The scantlings of masts and derrick posts supporting one or more derrick booms with a S.W.L. exceeding 15 tonnes and those of bipod or other special designs will be specially considered.

2802 A stayed mast or derrick post is one that is supported by one or more stays. A "stay" includes shrouds, forestays, backstays, etc.

Calculations—General

2803 The derrick or derricks are to be assumed to be initially at an angle of 30° to the horizontal or at the minimum angle specified (by the owner or builder) if this is less than 30°, the angles being measured when the ship is upright and without trim, but for calculations made with derricks swung outboard the effect of heel is to be taken into account if the heel of the ship is likely to exceed 5° with the derrick booms in this position and whilst working as swinging derricks carrying the full S.W.L.

Stayed Masts and Posts

2804 The scantlings of stayed masts and stayed derrick posts, and the required size of their associated stays are to be obtained from Table 51 by the method given in 2805 to 2811.

2805 Calculations should normally be submitted for the following conditions:—

(a) For masts with four derricks:—
  (i) with two derricks plumbing one hatch;
  (ii) with two derricks swung to their most outboard working position on one side of the ship.

(b) For masts with one derrick fitted forward and one aft:—
  (i) with one derrick at its greatest working outreach in a fore and aft direction;
  (ii) with both derricks swung to their most outboard working position on one side of the ship.

In each case the above derricks are to be considered as swinging derricks carrying the full S.W.L.

If other arrangements seem likely to give stresses significantly larger than either of the above, then a calculation is to be made for this "worst" configuration in addition to the others.

2806 The "Resultant of horizontal pulls of span tackles" is to be the resultant of the horizontal pulls of the span tackles of the derricks under load, plus any cargo runners that may be led to the mast head.

2807 The lengths of masts and posts are to be measured from the uppermost deck through which they pass to the mean intersection of the span and stay lines of action. (For this purpose, where a mast or post is supported by a deck house, the house top is to be regarded as a deck unless the house is specifically designed to give no effective support to the mast or post in both the transverse and fore and aft directions.)

Mast Scantlings

2808 The diameter and thickness of the mast or post at deck level is to be derived from Table 51A for the appropriate resultant pull of span tackles and mast length. The diameter and thickness of the mast or post at the hounds are assumed to be 85 per cent of the Table values.

Stay Sizes

2809 Stay sizes are to be determined by means of two factors; "B" and "C".

Factor B is to be obtained from Table 51A for the appropriate mast length and resultant pull of span tackles.

Factor C is to be obtained from Table 51B.

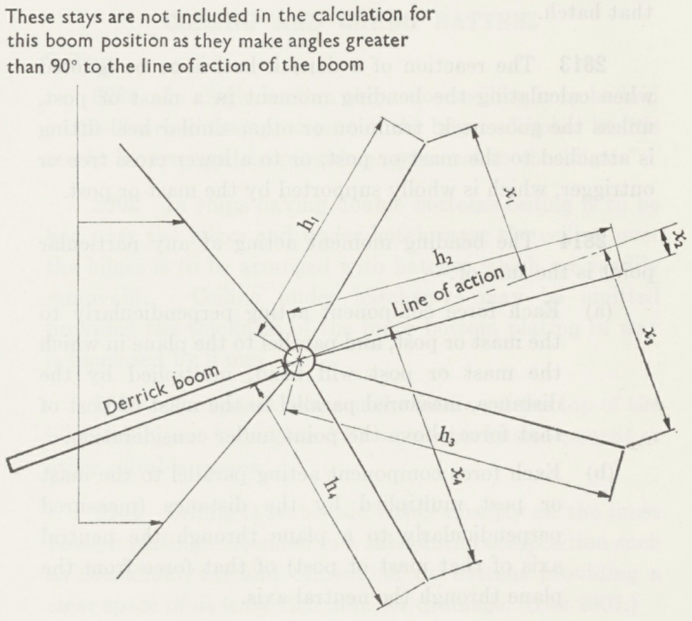
In Table 51B the symbols are as follows:—

h is the horizontal spacing of the mast-head stay eyeplate and the deck (or bulwark) stay eyeplate. h may vary for each stay (*see* Figure where varying values of h are shown as h_1, h_2, h_3 and h_4).

x is the horizontal distance from the deck (or bulwark) stay eyeplate to the line of action of the derrick boom (or mean line of action of the derrick booms if more than one will be in use). x may vary for each stay (*see* Figure).

v is the vertical spacing of the mast-head stay eyeplate and the deck (or bulwark) stay eyeplate. v may vary for each stay due to variations in deck or bulwark levels, but Table 51A is only applicable if the stays are attached to the mast at or near to the same level as the span tackle.

The values of $\frac{x}{h}$ and $\frac{h}{v}$ are to be used to obtain the appropriate value of factor C for each stay.



2810 The values of factor C for all stays are to be added and the required metallic cross sectional area of each stay is to be obtained from the following formula:—

$$\text{Area} = 645\,A_W = 645\,\frac{\text{Factor B}}{\text{Sum of Factors C}}\ \text{sq. mm.}$$

This formula assumes that all stays are the same size and construction and that the heights v in no case exceed the mast length by more than 1,25 metres.

If v, for any particular stay, does exceed the mast length by more than 1,25 metres then the metallic cross sectional area for that particular stay is to be increased in the ratio of $\frac{v}{\text{mast length.}}$

2811 The size of stays equivalent to various values of A_W are given in Table 51C for representative wire ropes, but exact values provided by the manufacturer of any particular rope are acceptable.

Stress Calculations—Unstayed Masts and Posts

2812 Where only one derrick is to be loaded at one time (e.g. a heavy derrick on the ship's centreline), or where two derricks may be loaded at the same time, but while working different hatches, the worst stresses, for rigs of normal design, can be assumed to occur with the derrick boom or booms swung outboard (on the same side of the ship if two booms are concerned).

Where two derricks are designed to work one hatch simultaneously, the worst stresses, for masts of circular section, can be assumed to occur with both booms plumbing that hatch.

2813 The reaction of a derrick heel is to be ignored when calculating the bending moment in a mast or post, unless the gooseneck, trunnion or other similar heel fitting is attached to the mast or post, or to a lower cross tree or outrigger, which is wholly supported by the mast or post.

2814 The bending moment acting at any particular point is the sum of:—

(a) Each force component acting perpendicularly to the mast or post, and parallel to the plane in which the mast or post will bend, multiplied by the distance, measured parallel to the mast or post of that force above the point under consideration.

(b) Each force component acting parallel to the mast or post multiplied by the distance (measured perpendicularly to a plane through the neutral axis of that mast or post) of that force from the plane through the neutral axis.

2815 The bending stress at each position on the mast or derrick post is to be calculated from the formula:—

$$f_B = \frac{M_m \times y}{I_m}$$

where f_B = bending stress at the position under consideration,

M_m = bending moment derived as specified in 2814,

I_m = moment in inertia of the mast at the height under consideration,

y = the distance from the neutral axis of the mast to the extreme outer surface at the height under consideration.

2816 The direct compressive stress acting on the mast is to be calculated by summing all the vertical components of span gear, derrick thrust, etc., as applicable, and the weight of the topmast and crosstrees if fitted, and dividing the total by the cross sectional area of the mast or post at the position under consideration.

The weight of the mast or post tube itself need not be included.

2817 The sum of bending and direct stresses derived from 2815 and 2816 is not at any point to exceed 0,55Y or 0,35U+0,05Y whichever is the least, if the S.W.L. of no derrick boom exceeds 10 tonnes. Where the S.W.L. of one or more derricks exceeds 10 tonnes then the stress may increase by 0,010Y or by 0,007U, whichever is the least, for each 4 tonne increase in the S.W.L. of the derrick with the highest S.W.L., where Y = specified minimum yield stress or 0,5% proof stress and U = specified minimum tensile strength plus one half of the specified range of tensile strength. For ordinary shipbuilding mild steel Y may be taken as 25 and U as 46.

The stresses in crosstrees, outriggers, and similar items are to be derived as for masts but using the highest S.W.L. of any derrick actually supported by the crosstree or outrigger.

2818 The effect of torque need not be included in calculating the stresses in masts of normal design, unless the span tackle eyeplate pins to which the derricks are attached to crosstrees or outriggers, are at a distance from the mast centreline exceeding $\frac{D^2\text{mm}}{645 \times \text{S.W.L.}}$

where D is the mast diameter at half height in millimetres. S.W.L. is the highest safe working load of any derrick supported by the crosstree or outrigger in question, in tonnes.

When torque is taken into account it is to be taken as:—

T = horizontal component of span tension x distance from span eye to centreline of mast or post.

Shear stress is to be taken as $q = \frac{T}{2At}$, where A is the total area enclosed by the outer surface of the mast or post

$\left(\text{for circular masts; } A = \frac{\pi\,(\text{diameter})^2}{4}\right)$

and t is the wall thickness of the mast or tube.

The total stress in the mast or post is:—

$$f_t = \tfrac{1}{2}\left(f_m + \sqrt{(f_m)^2 + 4q^2}\right)$$

where f_m is the stress value derived from 2817.

2819 The wall thickness, in millimetres, of oval or circular masts and posts is not to be less than:—

$\frac{D\sqrt{KY}}{350+2\times S.W.L.}$ or $\frac{D}{100}$ whichever be the greater,

where D = maximum outside diameter of the mast at corresponding height above the deck, in millimetres,

K = 1,00,

Y = yield stress in kg/mm²,

S.W.L. = maximum safe working load of any derrick supported by the mast, in tonnes.

The wall thickness, in millimetres, of unstiffened flat sides of masts or posts, with one or more flat side, is not to be less than:—

$\frac{W\sqrt{KY}}{200+2\times S.W.L.}$ or $\frac{W}{60}$ whichever is the greater,

where K, Y and S.W.L. are as defined above and W is the width, in millimetres, of the flat side at that height or 60% of the width of the mast at that height, measured parallel to the flat side, whichever is the greater.

Fittings and Details

2820 Masts and derrick posts are to be increased in thickness at the heel and decks and other points of support, and are to be suitably strengthened to take any concentrated loads which may be expected to occur in way of derrick fittings, crosstreees and ventilation openings. They should normally be attached to at least two decks other than the tops of winch houses and small deck houses of a type giving no effective support, but need not be attached to more than two decks or one deck and the top of a substantial house.

The heels of masts and derrick posts are to be effectively supported.

2821 The design and construction of masts, posts and fittings is to be such as to reduce the likelihood of water collecting in inaccessible parts of the structure.

2822 For lightning conductors *see* M 19.

Workmanship

2823 Smithwork should be of a material not liable to work hardening or ageing to a significant degree during normal use.

Rimming steel should not be used.

Where fittings are flame cut from solid material they are to be annealed after cutting and all flame cut faces are to be ground if necessary to give a smooth finish to avoid stress raisers.

Crosstrees

2824 Where outriggers or crosstrees at mast-heads are of unusual spread or where stays are attached to the crosstrees well clear of the mast, the scantlings of the mast and rigging will be specially considered.

The stresses in crosstrees should not normally exceed 55 per cent of the yield stress of the material or (for items under compression) of the crippling stress of that item.

Section 29

CEILING AND CARGO BATTENS

Ceiling

2901 In single bottom ships close ceiling is to be laid on the floors to the upper part of the bilges. Limber boards are to be arranged to provide easy access to the bilges.

2902 In ships having double bottoms ceiling is to be laid over the bilges and under hatchways; the ceiling over the bilges is to be arranged with hatches which are readily removable. Ceiling under hatchways may be omitted provided the thickness of the inner bottom plating in way is increased by 2 mm.

2903 The spaces between the frames at the top of the bilge ceiling are to be closed by wood chocks and cement or other suitable means.

2904 Ceiling is to be laid either directly on the inner bottom plating embedded in a substantial composition such as Stockholm tar and cement, or on battens providing a clear space of at least 12,5 mm. for drainage. (*See* 2907.)

2905 The thickness of wood ceiling is to be not less than 65 mm. in ships exceeding 61 metres in length nor less than 50 mm. in smaller ships.

2906 Where the covers or fittings of the manholes of the inner bottom in cargo holds project above the plating they are to be protected by a steel coaming around each manhole, fitted with a hatch of wood or steel.

Cross-references

2907 The requirements for ceiling over double bottom tanks where oil fuel is carried are given in D 2027.

2908 For ceiling in ships which are to be regularly discharged by grabs, *see* D 525.

For arrangements in way of refrigerated holds, *see* N 415 and N 416.

Cargo Battens

2909 Cargo battens are to be fitted in the holds from above the upper part of the bilge to the under side of beam knees, and in all cargo spaces in 'tween decks and superstructures up to the under side of beam knees.

2910 Wood cargo battens are to be 50 mm. in thickness in ships exceeding 61 metres in length and 40 mm. in smaller ships; the clear space between the adjacent rows is not to exceed 230 mm.

2911 Battens may be dispensed with at the request of the Owners; the notation "NS" will appear in the Register Book.

Section 30

PROTECTION OF STEELWORK

Cementing

3001 In single bottom ships the shell plating and framing to the upper part of the bilges are to be effectively covered by an approved type of cement, asphalt or other coating. Free edges of the coating are to be of proper thickness, clear watercourses are to be maintained throughout.

3002 In double bottom tanks under the boiler room the frames and shell plating are to be effectively covered by an approved type of cement or other coating unless the tanks are used solely for oil fuel; elsewhere in the double bottom the cement or coating may be dispensed with. The bilges are to be cemented or effectively coated.

Painting

3003 All steelwork not protected as required by 3001 and 3002 is to receive at least two coats of paint of suitable composition except inside tanks intended for oil; tanks not intended for oil may be coated with cement wash. (*See* F 822 and F 1005).

General

3004 Millscale should be removed from external shell plating, and it is recommended that shot blasting, pickling or other equally effective means be employed for this purpose. If flame-cleaning is adopted, it is to be followed by wire brushing or grinding. Where reliance is placed on weathering and wire brushing, the coating of the external surface should be delayed as long as possible to facilitate the removal of the millscale.

3005 When the millscale is removed by methods less effective than shot blasting, it is desirable when several months elapse between the launching and commissioning to dry-dock the ship immediately before she goes into service. In these circumstances also it is desirable to dry-dock a ship when she has been about six months in service.

Section 31

WELDED CONSTRUCTION

General

3101 Where electric arc welding is to be used for the main structure the arrangement of the plating, disposition and type of joints, together with the proposed sequence of prefabrication, assembly and welding, are to be submitted for approval. The extent to which automatic welding is to be used should be indicated.

Details of welded connections of main structural members with type and size of welds are to be clearly indicated on the plans submitted for approval.

The approved arrangements, sequences and procedures are not to be departed from without approval.

3102 The structural arrangements are to be such as will admit of easy access for welding operations and will facilitate the use of downhand welding wherever possible.

The type and disposition of connections and sequences of welding are to be so planned that any restraint during welding operations is reduced to a minimum.

3103 The electrodes are to be approved by the Committee and are to be suitable for the type of joint. The requirements for electrodes are given in P 15.

Quality of Material

3104 For ships of 91,5 metres in length and over, in which the seams and butts of the shell plating and strength deck are welded, steel of Grade D (*see* P 2 Table II) will generally be required for the following parts of the main structure when the thickness exceeds 20,5 mm.:—

Sheerstrake, stringer plating and deck plating of strength deck within 0,4L amidships and plating at breaks of superstructures and corners of openings outside 0,4L amidships.

Bottom shell to upper turn of bilge within 0,4L amidships. When the bottom shell is of Grade D steel, the keel is also to be of that grade.

Any sheerstrake or stringer plate outside the above limits which exceeds 25,5 mm. in thickness should also be Grade D.

When necessary the application of the above requirements to ships less than 91,5 metres long will be specially considered.

3105 In ships over 106,5 metres in length, a riveted stringer angle, or alternatively a gunwale construction incorporating steel of specially high notch toughness (Grade E), may be required.

Refrigerated Ships

3106 In addition to the requirements of 3104, where the arrangements are such that the temperature of the steel of the deck may be reduced to that given below, the deck plating and the webs of girders attached thereto shall comply with the following requirements:—

STRENGTH DECK

Temperature	*Grade of Steel*	
	0,5L *amidships*	*At Ends*
Below +5° C. (41° F.) but not below —5° C. (23° F.)	D	D
Below —5° C. (23° F.) but not below —20° C. (—4° F.)	E	D
Below —20° C. (—4° F.)	Steel conforming to the requirements of Grade E at the temperature concerned.	

SECOND AND LOWER DECKS

Below —5° C. (23° F.).	D	D

Special consideration will be given to cases where the width of affected material is considerably less than the width of the hatchways.

3107 For the purposes of 3106 the temperature to which the steel deck may be reduced is to be assessed as follows:—

Arrangement	*Deck Temperature*
1. Deck not covered with insulation in the refrigerated space.	Temperature of the refrigerated space.
2. Deck covered with insulation in the refrigerated space and not insulated on the other side.	Temperature of the space on the uninsulated side.
3. Deck covered with insulation on both sides.	(a) Mean of the temperatures of the spaces above and below the deck provided the difference in the temperatures is not more than 11° C. (20 F.) (b) Mean of the temperatures of the spaces above and below the deck less 3° C. (5° F.) if the difference in the temperatures is more than 11° C. (20° F.) but not more than 33° C. (60° F.). (c) When the temperature difference is more than 33° C. (60° F.) the deck temperature will be specially assessed.

When one of the spaces concerned is not refrigerated, the temperature of that space is to be taken as 5° C. (41° F.).

Structural Details

3108 Special attention is to be paid to structural continuity. Abrupt changes of shape or section and all sharp corners are to be avoided. The plating at corners of all openings in strength decks and shell plating is to be well rounded.

Where the deck is connected to the main hatchway coamings by welding, the deck opening and the coamings at the corners of the hatchways are to be rounded with a radius which, for openings within ·3L forward and aft of amidships, is not to be less than $\frac{1}{24}$ of the breadth of the opening; the minimum radius at all main hatchways in the strength deck is to be 150 mm.

If the deck plating extends inside the coamings the coamings may be square at the corners, provided that, within ·3L forward and aft of amidships, the side coamings are extended in the form of a tapered bracket and the

deck plating at the corners is rounded as required by the preceding paragraph; the minimum radius is to be 300 mm. for hatchways within ·3L forward and aft of amidships or 150 mm. for those forward or abaft this region.

Where the deck is connected to the coamings by welding, the strength deck plating at the corners of all large openings is to be increased in thickness; welded doubling plates are not to be fitted. The seams and butts of the deck plating are to be kept well clear of hatch corners.

Where the deck plating stops at the coaming and is welded thereto, through penetration welds are to be used. Where the deck plating extends inside the coaming, the free edges of the plating in way of the hatchways are to be smooth and free of weld attachments.

Arrangements at the welded corners of machinery casings will be specially considered.

3109 Bulwarks, fairlead stools, mouldings, or other fittings are not to be welded to the top of the sheerstrake within 0,5L amidships. The top edge of the sheerstrake is to be free of all notches and is to be smooth.

The endings of bulwarks, bilge keels or similar attachments to the hull are to be gradually tapered.

3110 Frames, floors, stringers, girders, stiffeners and wash bulkheads in the aft peak, or on the aft peak bulkhead, are not to be scalloped and the connection to shell or bulkhead is to be by double continuous welds.

Hold and 'tween deck frames supporting cantilever beams are not to be scalloped.

3111 When stiffening members cross completely finished butt or seam welds, these welds are to be made flush in way of the faying surface. Similarly, for butt welds in webs of stiffening members the butt weld should be completed and generally made flush with the stiffening member before the fillet weld is made.

Where these conditions cannot be complied with a scallop is to be arranged in the web of the stiffening member. Scallops are to be of such a size, and in such a position, that a satisfactory weld can be made.

Bilge keels should also be scalloped at their butts, or alternatively, a 25 mm. hole should be drilled in the butt weld just above the fillet weld. In this case the fillet weld is to be continuous.

Local concentration of welds should be avoided.

Where thick plates are butt welded to thin plates the edge of the thick plate may require to be chamfered.

3112 Individual connections part welded and part riveted are to be avoided and shall not be adopted unless specially approved.

3113 The thickness of plating may in certain cases require to be increased to take account of the greater area of panels resulting from the omission of faying flanges of the supporting structure.

Welded Joints and Connections

3114 Butt Welds Butt welds should be adopted in preference to overlaps for joints in the main structure. In general, the edges of plates to be joined by manual welding are to be bevelled on one side or on both sides of the plates to provide an included angle of from 50 to 60 degrees.

Where it is desired to adopt other forms of edge preparation full details are to be submitted for approval.

A back sealing run is to be applied after suitable back gouging to all butt welds where main welding is carried out from one side only unless the welding process has been specially approved for use without a back run.

3115 Fillet Welds The dimensions of fillet welds for various structural connections are to be as required by Table 52.

3116 Tee Connections The leg length of the fillets is to be governed by the thickness of the abutting plate or web. Where the difference between the thicknesses of the parts to be joined is considerable, the size of the fillet will be specially considered.

Tee connections should be made by fillets on both sides of the abutting plate. Where the abutting plate is bevelled a sealing run should be applied on the reverse side.

3117 Intermittent Fillets The length of intermittent welds is to be measured over the correctly proportioned fillet, clear of end craters.

Intermittent welds are to be doubled at the ends of all structural members, also the welding is to be carried round the ends of brackets, lugs, etc.

3118 Scallops and Notches The details of scalloped construction are given in Table 52 G. All scallops are to have well rounded corners and smooth edges. Scallops are not to be cut in way of the toes of bracket connections or at other parts where stress concentrations may develop.

Scallops in side frames, longitudinals and stiffeners are to be omitted for at least 230 mm. on each side of the intersection with a primary supporting member.

Notches in primary supporting members are not to be larger than necessary, and are to have well rounded corners and smooth edges. When notches occur at points where

stress concentration may develop, such as adjacent to the toes of brackets, a welded collar or equivalent reinforcement is to be fitted.

Additional Attachment

3119 Welded connections may be required to be increased to meet particular local stresses, or where otherwise necessary.

Overlap Joints

3120 Where overlapped joints of plating are adopted, the breadth of the overlap is to be four times the thickness of the thinner of the plates so joined, but need not exceed 50 mm.

Workmanship

3121 Welding operators are to be proficient in the type of work on which they are engaged. A sufficient number of skilled supervisors is to be provided to ensure effective control at all stages of assembly and welding operations. The welding plant and appliances are to be suitable for the purpose intended and are to be maintained in an efficient condition.

3122 Procedures for the welding of all joints are to be established for the types of electrode, edge preparation and welding position proposed. For this purpose, the Surveyors may require sample tests to be prepared under similar conditions to those which will obtain during construction.

The diameter of electrode, current, voltage, rate of deposit and number of runs are to conform, as far as practicable, to those established in accordance with the preceding paragraph. Provision is to be made for checking the current in the vicinity of the arc.

3123 The preparation of plate edges is to be accurate and uniform. All joints are to be properly aligned and closed or adjusted before welding. Excessive force is not to be used in fairing and closing the work. Means are to be provided for holding the work in proper alignment without rigid restraint during welding operations.

Where excessive gaps exist between surfaces or edges to be joined, the corrective measures adopted are to be to the satisfaction of the Surveyors.

3124 Tack welding should be kept to a minimum and where used the tack weld should be equal in quality to the finished welds. All defective tack welds should be cut out before completing the finished welds.

Care should be taken when removing tack welds and temporary fittings used for assembly to ensure that the material of the hull is not damaged.

3125 The surfaces of all parts to be welded are to be clean, dry and free from rust, scale and grease. The surfaces and boundaries of each run of deposit are to be thoroughly cleaned and free from slag before the next run is applied.

Before a sealing run is applied to the back of a manual weld, the original root run is to be cut back to sound metal.

Welding is to proceed systematically, each welded joint being completed in proper sequence without undue interruption.

Adequate protection is to be provided where welding is required to be carried out in exposed positions in wet, windy or cold weather. In cold weather, precautions should be taken to screen and pre-warm the work to prevent too rapid cooling of the weld; special care is necessary when welding thick material.

3126 All finished welds are to be sound, uniform and substantially free from slag inclusions, porosity, undercutting or other defects. Care is to be taken to ensure thorough penetration and fusion.

3127 Where the structure embodies both welding and riveting, welded joints are in general to be completed before riveting in their vicinity.

Primers and Coatings

3128 Where primers are applied to plates over areas which will subsequently be welded they are to be of a quality approved by the Society as having no deleterious effect on the finished weld.

For preservative coatings, *see* D 1914.

Inspection

3129 Effective arrangements are to be made for the inspection of finished welds to ensure that welding has been satisfactorily completed.

Visual inspection is to be supplemented by a system of radiographic examination or other approved method of non-destructive crack or flaw detection. The extent of such examination is to be to the Surveyor's satisfaction but particular attention should be paid to the following locations:—

(*a*) Junctions and crossings of seams and butts in strength deck, sheerstrake, side, and bottom shell within 0,5L amidships.

(*b*) Butts of keel plating and rounded sheerstrake within 0,5L amidships.

(*c*) Insert plates in way of hatch openings in the strength deck.

All defective sections of welds are to be cut out, carefully re-welded and re-examined.

3130 Alternative proposals for methods of welding considered by the Committee to be equivalent to those set forth in the Rules will be accepted.

Welding of Aluminium Alloys

3131 Where welding of aluminium alloys is employed, the requirements as laid down in this section are to be carried out in so far as they are applicable, with the following additions:—

The edges of the material to be welded are to be clean and freed from grease by chemical or solvent cleaning.

The joint edges should be scratch brushed—preferably immediately before welding—in order to remove oxide or adhering films of dirt, filings, etc.

Parts to be welded should be set up in such a way that contraction stresses are kept to a minimum.

For welding processes and filler wire, *see* P 18.

Section 32

RIVETED CONSTRUCTION

Riveted Connections

3201 The requirements for riveted connections and the diameter and spacing of rivets in the various parts of the structure are given in Table 52. The diameter of the rivets is to be regulated, in general, by the greater thickness of the parts to be connected, but where the difference is considerable special consideration will be given. (*See also* Notes to Table 52.) Where frame spacing wider than that given in the Tables is adopted the diameter and the number of rows of rivets are to be regulated by the thickness of the plating required at the Table frame spacing.

3202 The breadths of the flanges of connecting angles or other sections are to be generally not less than four times the diameter of the rivet for rivets up to 22 mm. in diameter and three and one-half times for rivets of 25 mm. diameter or over.

3203 Chain riveting is to be adopted for the butts and seams of plating. In the connections to bar keels, stems and sternframes and in double riveted stringer angles, boundary angles and frame connections, the rivets are to be reeled.

Form of Rivets

3204 Rivets are to be suitably formed to fill the rivet holes completely. Where the holes have been punched the rivets are to be increased under their heads. The heads of pan headed rivets are to have a depth of 0,7 and a diameter at the bottom of the head of 1,6 times the diameter of the rivet. Where countersunk headed rivets are used the heads are to be suitable for the countersinking of the material.

Countersinking

3205 Rivet holes are to be countersunk on the caulking side of plating, and in boundary connections of shell, weather decks, inner bottom, double bottom tank ends, crowns and bulkheads of peak tanks, deep tanks and oil fuel bunkers. The holes in the margin plate to take gusset rivets are also to be countersunk.

3206 The depth and angle of countersink are to be as shown below depending on thickness of material:—

Thickness Millimetres	Countersink	
	Approx. Depth	Approx. Angle
Not exceeding 12,5 ...	90 per cent	60°
Above 12,5 and not exceeding 25,5 ...	80 per cent	45°
Exceeding 25,5 ...	66 per cent	35°

NOTE.—No countersink need exceed 20,5 mm.

Workmanship

3207 Workmanship is to be well executed and submitted to close inspection throughout the preparation and building of the ship. The various parts of the structure are to be faired and properly closed.

3208 Punches, dies and shears are to be maintained in good condition and the clearance between the punch and the die is to be kept as small as possible.

Plating

3209 The preparation of plate edges is to be accurate and uniform. Shearing is to be carried out from the faying surface wherever practicable. Any burr on plates or sections preventing the closing of work is to be removed.

3210 All caulking edges are to be planed, flame cut, chipped fair, or otherwise suitably prepared.

Liners and Joggling

3211 Where plates or sections are joggled care is to be taken that the joggle is of the correct depth and rivet holes are to be clear of the joggle.

3212 Liners, if fitted, are to be in one piece of the proper thickness and of breadth not less than the flange of the faying section. Holes in liners are to be of the same diameter as those in the plate and section.

Riveting

3213 Rivet holes may be drilled or punched and are to be countersunk where required by 3205 and 3206. Punching is to be carried out from the faying surface wherever practicable.

3214 Any burr caused by drilling or punching is to be removed before the work is closed for riveting.

3215 Unfair rivet holes are to be remedied by reamering and rivets of an appropriate diameter are to be used. Where necessary the holes are to be recountersunk and the faying surfaces cleaned.

3216 Rivet holes in the frames at the turn of the bilges and at bossing are not to be drilled or punched to their full diameter before the frames have been shaped.

3217 Service bolts of requisite size and number are to be used to hold the parts in position and in close contact.

3218 The heads of the rivets are to be properly laid up and the work performed so that the holes are completely filled. Points of the rivets are to be kept full but are not to be spread over the plating. In holes which are not countersunk the rivets are to be finished with specially full or snap points.

3219 Rivets in all parts are to be spaced to ensure the efficient closing of work. Particular care is to be taken with three-ply riveting.

Caulking

3220 Caulking is to be thoroughly executed. Stopwaters of suitable material may be fitted where necessary; otherwise the use of soft packing is to be kept to a minimum. Thick packing is not to be used.

Oil-tight Riveted Work

3221 The requirements of 3201 to 3220 are to be complied with.

3222 Faying surfaces are, in general, to be fitted steel to steel; but where packing is necessary the material used is to be as thin as possible and not soluble in oil.

3223 Where there may be difficulty in securing fairness, rivet holes are to be drilled in position or punched small and reamered.

3224 Where boundary angles are double both flanges of each bar are to be caulked and countersunk headed rivets are to be used.

3225 Where fitted on caulking surfaces angle or T-bar connections are to be caulked.

3226 Where the plating is pierced for the attachment of fittings, the method adopted is to be approved.

Section 33

EQUIPMENT

General

3301 The regulations governing the assignment of the figure 1 for equipment are contained in B 201 and B 202.

3302 To entitle a ship to the figure 1, the equipment is to be in accordance with the following requirements and Table 53. For ships engaged on a special or restricted service, an equipment differing from the Table requirements may be approved by the Committee if considered suitable for the particular service on which the ship is to be engaged.

Equipment Number

3303 The equipment of anchors, chain cables, wires and ropes given in Table 53 and associated notes is based on an "Equipment Number" which is to be calculated as follows:—

$$\text{Equipment Number} = \Delta^{\frac{2}{3}} + 2Bh + \frac{A}{10}$$

where Δ = moulded displacement, in tonnes, to the summer load waterline,

B = greatest moulded breadth, in metres,

h = effective height, in metres, from the summer load waterline to the top (at side) of the uppermost house having a breadth greater than $B/4$. (*See also* 3304, 3305 and 3306),

A = area, in square metres, in profile view, of the hull, superstructures and houses above the summer load waterline, which are within the rule length of the vessel, and also having a width greater than $B/4$. (*See also* 3305 and 3306).

3304 When calculating h, sheer and trim are to be ignored, i.e. h is the sum of the freeboard amidships plus the height (at side) of each tier of houses having a breadth greater than $B/4$.

3305 If a house having a breadth greater than B/4 is above a house with a breadth of B/4 or less, then the wide house is to be included, but the narrow house ignored.

3306 Screens and bulwarks more than 1,5 metres in height are to be regarded as parts of houses when determining h and A.

Anchor Weights

3307 The weight per anchor, of bower anchors, given in Table 53 is for anchors of equal weight. The weight of individual anchors may vary by ± 7 per cent of the Table weight provided that the total weight of anchors is not less than would have been required for anchors of equal weight.

3308 The weight of the head, including pins and fittings, of an ordinary stockless anchor is not to be less than 60 per cent of the total weight of the anchor.

3309 When stocked bower or stream anchors are to be used, the weight "ex-stock" is to be not less than 80 per cent of the Table weight for ordinary stockless bower anchors. The weight of the stock is to be 25 per cent of the total weight of the anchor, including the shackle, etc., but excluding the stock.

3310 When anchors of a design approved for the designation "High Holding Power Anchor" are used as bower anchors, the weight of each such anchor may be 75 per cent of the Table weight for ordinary stockless bower anchors.

Anchor Design

3311 Anchors are to be of approved design. The design of all anchor heads is to be such as to minimise stress concentrations and, in particular, the radii on all parts of cast anchor heads are to be as large as possible, especially where there is a considerable change of section.

3312 For approval as a "High Holding Power" anchor, satisfactory tests are to be made on various types of bottom, and the anchor is to have a holding power at least twice that of an "Admiralty Standard Stockless" anchor of the same weight.

Chain Cables

3313 Chain cables may be of wrought iron, mild steel, special quality steel or extra special quality steel in accordance with the requirements of P 13.

3314 Chain cables are to be graded as follows (*see also* P 1301 and P 1302):—

GRADE	MATERIAL	U.T.S. KG PER MM^2
1(a) 1(b) U 1(a)	Wrought iron Mild steel Mild steel	Exceeding 31 but not exceeding 41
U 1(b)	Mild steel	Exceeding 41 but not exceeding 50
U 2(a)	Special Quality steel	Exceeding 50 but not exceeding 65
U 2(b)	Special Quality cast steel	Exceeding 50 but not exceeding 70
U 3	Extra Special Quality steel	Exceeding 70

3315 Grades 1(a), 1(b) or U 1(a) materials are not to be used in association with high holding power anchors.

Grade U 3 material is only to be used for chain 40 mm. or more in diameter.

3316 When stream anchors are used in association with chain cable, this cable may be either stud link or short link.

3317 The form and proportion of links and shackles are to be in accordance with recognised practice.

Stream Wires, Tow Lines and Mooring Lines

3318 Tow lines and mooring lines may be of wire, natural fibre or synthetic fibre material, or of a mixture of wire and either natural or synthetic fibre. The diameter, construction and specification of wire or natural fibre tow lines and mooring lines are to comply with the requirements of P 14.

Where it is proposed to use synthetic fibre ropes the size and construction will be specially considered.

3319 The lengths of individual mooring lines may be reduced by up to 7 per cent of the Table length, provided that the total length of mooring lines is not less than would have resulted had all lines been of equal length.

Testing of Equipment

3320 All anchors and chain cables are to be tested at establishments and on machines recognised by the Committee under the supervision of the Society's Surveyors or other Officer recognised by the Committee, and in accordance with P 11 and P 13.

3321 Test certificates showing particulars of weights of anchors, or size and weight of cable and of the test loads applied are to be furnished. These certificates are to be examined by the Surveyors when the anchors and cables are placed on board the ship.

3322 Steel wire and fibre ropes are to be tested as required by P 14.

Arrangements for Working and Stowing Anchors and Cables

3323 A windlass of sufficient power and suitable for the size of chain cable is to be fitted and efficiently bedded and secured to the deck. The thickness of the deck in way of the windlass is to be increased and adequate stiffening is to be provided, to the Surveyor's satisfaction.

3324 An easy lead of the cables from the windlass to the anchors and chain locker is to be arranged.

3325 Hawse pipes are to be of ample thickness and of a suitable size and form to house the anchors efficiently. Substantial chafing lips are to be provided at the shell and deck. The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

3326 The chain locker is to be of a capacity and depth adequate to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. Chain or spurling pipes are to be of suitable size and provided with chafing lips. The port and starboard cables are to be separated by a division in the locker, and provision is to be made for securing the inboard ends of the cables to the structure.

3327 Satisfactory arrangements are to be made for the stowage and working of the stream anchor if provided.

Cross-reference

3328 For the equipment of tugs *see* D 3511.

Section 34 (*See* Note on page 29)

RECOMMENDATIONS IF ADDITIONAL STRENGTHENING FOR HEAVY CARGOES IS DESIRED

General

3401 The following recommendations are inserted for the guidance of Owners who desire to provide additional strengthening to ships regularly engaged in onerous heavy cargo trades. (For Bulk Carriers, *see* D 37).

3402 Where the class contemplated includes loading other than homogeneous, schemes of loading covering the cargo and ballast conditions envisaged are to be submitted for approval.

3403 The scantlings, arrangements and equipment should be as required by Sections D 1 to D 33, modified as follows.

Structural Design

3404 The double bottom and strength deck should be longitudinally framed.

Double Bottom Structure

3405 Plate Floors. Under cargo holds abaft 0,25L from forward plate floors should be fitted on alternate frames in way of the hatchways, but may be on every third frame, with maximum spacing of 2,45 metres clear of hatchways.

3406 Inner Bottom Longitudinals. The section modulus of the inner bottom longitudinals shall be derived from Table 10 and associated notes increased by 20 per cent in way of the hatchways and 10 per cent clear of the hatchways.

Struts should not be fitted to the longitudinals between the floors.

3407 Centre Girder. When the maximum spacing of the plate floors is 2,45 metres, the height of the centre girder should be increased 20 per cent above that required by Table 6; when the maximum spacing of floors is 1,85 metres or less, the height of the centre girder may be as required by Table 6.

3408 Side Girders. Side girders should be not less than required by D 503.

An additional side girder should be fitted abaft the engine room, extending the full length of the hold.

3409 Inner Bottom Plating. The thickness of the inner bottom plating should be increased by 5 mm. above the requirements of Table 6 or alternatively double ceiling should be fitted.

Side Framing

3410 In the holds the height of the tank side brackets above the tank top as required by Tables 6 and 11 should be maintained. The arms of the lower deck beam knees should be increased by 150 mm. and the riveting correspondingly increased. The frames and beams should not be reduced in size on account of this increase.

Decks

3411 The sectional area of the strength deck plating as derived from Table 18 and associated notes should be increased by 10 per cent for 0,4L amidships.

3412 STRONG HATCH SIDE COAMINGS AND END BEAMS UNDER CARGO DECKS. The scantlings should be determined by the numeral derived from the notes to Table 29 increased by 10 per cent.

Section 35

TUGS

General

3501 The scantlings and arrangements of tugs are to be as required by the preceding Sections of this Chapter except where otherwise specified in this Section.

The draught d used for determination of scantlings, is not to be less than 0,85D.

Class

3502 Tugs built in accordance with the requirements of this Section will be classed 100A1 tug.

3503 Where tugs are intended for service in sheltered waters only, the class will be A1 tug with a class notation indicating the limits of the service. Suitable modifications in the scantlings, arrangements and equipment may be approved by the Committee.

Floors

3504 Floors in tugs having single bottoms may be flanged 90 mm. on the upper edge instead of having reversed frames, except in the engine room and under the boiler bearers where double reversed frames are to be fitted as required by D 407.

Keelsons

3505 The scantlings of keelsons are to be in accordance with the requirements for tugs given in Table 5.

Bulkheads

3506 Watertight bulkheads are to be constructed generally as required by D 16, but the stiffeners may be determined from Table 35.

Machinery Casings

3507 Machinery casings are to be not less in height than 915 mm. above the upper surface of the deck.

Casings extending to the bottom of the beams are to be connected to the beams; the deck connection may be made by a single riveted angle or equivalent. If the casings do not extend to the bottom of the beams the casing connection to the deck is to be double riveted or equivalent.

3508 Machinery casings are to be made watertight and hose tested.

3509 A strong through beam is to be fitted at the deck level between the engine room and boiler room openings. A through beam should also be fitted in motor tugs when the machinery opening is of considerable length, and the casing stiffened by webs.

Panting and Strengthening of Bottom Forward

3510 The arrangements to resist panting, required by D 9, do not apply to tugs below 45,7 metres in length. In tugs 45,7 metres or more in length additional stiffening is also to be fitted in the 'tween decks throughout the panting region.

The requirements of D 8 for strengthening of bottom forward do not apply to tugs.

Equipment

3511 The regulations governing the assignment of the figure 1 for equipment are defined in B 201 and B 202.

3512 The equipment of anchors, chain cables, wires and ropes given in Table 54 and associated notes is based on an "Equipment Number" which is to be derived as follows:—

Equipment Number $= L(B+D)$,

where L = length of the vessel, in metres,

B = greatest moulded breadth, in metres,

D = moulded depth amidships, in metres.

Where the Equipment Number so derived exceeds 1300 the equipment is to be as required by Note 1 to Table 54.

3513 The remaining requirements of D 33 are to be complied with as appropriate.

Section 36

DREDGERS AND HOPPER BARGES

General

3601 The scantlings and arrangements of dredgers and hopper barges are to be as required by the preceding Sections of this Chapter except where otherwise specified in this Section.

The draught d, used for the determination of scantlings, is generally to be that corresponding to the minimum freeboard, but when a restricted draught is desired, this may be used with a minimum value of 0,7D.

Class

3602 These rules apply to two classes of ships; those intended to work in estuaries or adjacent waters and proceeding only a short distance outside coastal limits for the purpose of dumping spoil, and those which are required to proceed considerable distances to sea for the purpose of dumping spoil or are intended to make regular voyages between ports. Ships in the former category will be classed 100A1 Dredger, 100A1 Hopper Dredger or 100A1 Hopper Barge, with a suitable service notation; those in the latter will not have a service limit.

The rules are basically designed to cover ships having a restricted geographical service and the increases required for an unrestricted service are also given.

3603 When dredgers and hopper barges are intended for service in sheltered waters only, the class will be A1 Dredger, A1 Hopper Dredger or A1 Hopper Barge with a class notation indicating the limits of the service. Suitable modifications in the scantlings, arrangements and equipment may be approved.

3604 When dredgers and hopper barges are to be classed for unrestricted service but, while operating in restricted waters, may be loaded to a draught greater than that used for determining scantlings, particulars of the draught desired and service limits are to be submitted for approval. If the resulting freeboard is less than the minimum assignable under the Load Line Convention the agreement of the appropriate national or local authorities may also be required.

Longitudinal Strength

3605 In way of the hopper the modulus of the section is not to be less than:—

$$\frac{I}{y} = \frac{(6{,}6737L^2 + 26{,}247L + 11000)}{4{,}732} Bd \text{ cm}^3$$

where L = length of ship, in metres (*see* D 201),
B = moulded breadth, in metres,
d = scantling draught, in metres.

In computing the modulus all continuous material (e.g., hopper sides, bottom, deck and hopper side longitudinals) is to be included.

3606 Consideration will be given to the required section modulus for dredgers or barges not having service limits and also to those with relatively short hoppers. In these cases particulars of the main hull and machinery weights, displacement, etc., are to be provided to enable a longitudinal strength calculation to be made. Alternatively, the Builders' calculation of still water bending moment is to be submitted.

Floors

3607 Where single bottoms are fitted the depth of the floors may be 5 per cent less than that given in Table 4, and the floors may be flanged on the upper edge instead of having reversed frames, except in the engine room and under the boiler bearers where double reverse frames are to be fitted. Where floors are flanged the breadth of the flange is to be the same as that of the horizontal flange of the reverse frame required by Table 4.

3608 The floors abreast the hopper or well opening may be 5 per cent less in depth than required by Table 4, based on a breadth equal to the breadth of the ship B minus the total breadth of the hopper or well openings. The depth of the floors is not, however, to be less than 70 per cent of the depth based on the full value of B.

3609 Floors abreast the hopper are to be bracketed at each end but clear of the hopper the brackets may be omitted provided suitable compensation is arranged.

Side Keelsons

3610 Clear of the hopper opening side keelsons are to be fitted as required by D 412 and D 416.

A side keelson is to be fitted in the buoyancy space abreast the hopper opening when the distance between the hopper opening and the ship's side exceeds 3,65 metres.

Longitudinal Framing

3611 Where longitudinal framing is adopted either with a double bottom or in association with open floors, the modulus of the longitudinals may be 10 per cent less than that given by Table 10 and associated notes except for unrestricted service.

3612 Where the longitudinals are supported by open floors the scantlings of the floors are to be as given by the following formula:—

$$\frac{I}{y} = C \times l^2 \times s \times D \text{ cm.}^3$$

where l = span of floor, in metres, measured to the mid-points of the end brackets,
s = spacing of floors, in metres,
D = depth of ship to upper deck at amidships, in metres,
C = 10,0 for restricted service or 10,845 for unrestricted service.

The modulus of the floor is to be calculated in association with 610 mm. of shell plating.

The depth of the floor is not to be less than $2\frac{1}{2}$ times the depth of the slot for the longitudinal.

Side Framing

3613 The side frames clear of the hopper are generally to be in accordance with the requirements of D 6. The modulus may be 10 per cent less than required by Tables 12 and 13, except for unrestricted service (*see also* 3617). The depth h to be used in Table 12 is to be measured at 0,25L from the fore end, for framing between that point and the collision bulkhead.

Shell Plating

3614 The shell plating and sheerstrake are to be generally in accordance with the requirements of D 7 and Tables 14 and 18, but the thickness given in the Tables may be reduced by 5 per cent except for unrestricted service. In transversely framed ships with welded bottom plating the thickness of the plating need not be increased as required by D 708; the shell stiffeners required by that paragraph are to be fitted, but the scantlings of the stiffeners may be reduced in ships less than 76,2 metres in length.

3615 The corners of hopper openings are to be well rounded, but doublings or plating of increased thickness need not be fitted except for unrestricted service.

Strengthening of Bottom Forward

3616 The requirements of D 8 for strengthening of bottom forward do not, in general, apply to dredgers and hopper barges.

Where the service is unrestricted, the midship thickness of the bottom shell plating (clear of hopper) is to be carried to the fore peak bulkhead and the requirements of D 805 and D 806 complied with.

Arrangements to resist Panting

3617 Strengthening to resist panting is not required to be fitted between 0,15L from the fore end and the collision bulkhead except that for unrestricted service the strength of the framing in this area is to be increased by 10 per cent.

Hopper

3618 In way of the hopper the side framing and hopper side stiffening may be arranged either transversely or longitudinally. Where transverse framing is fitted the side frames and hopper side stiffeners are to be supported by struts, or stringers in association with struts, or equivalent arrangements, except in very small vessels. Where longitudinal framing is fitted, the longitudinals are to be supported by webs or transverses.

3619 The transverse side frames are to be in accordance with the requirements of D 6 and, except for unrestricted service, the modulus may be 10 per cent less than required by Table 12, the depth h being measured to the upper deck amidships. Where struts or stringers in association with struts are fitted, the modulus of the frames so determined may be reduced by 20 per cent. The hopper side stiffeners where fitted transversely are to be determined as deep tank stiffeners from Table 40, H being taken to the overflow and length being measured along the stiffener; the modulus so obtained may be reduced by 20 per cent where struts or stringers in association with struts are fitted.

3620 The section modulus of side frames arranged longitudinally is to be obtained by multiplying that of the bottom longitudinals derived from Table 10 (corrected as necessary for draught, spacing and service) by the factor

$$\frac{h+0,61}{D}$$

where h = distance of longitudinal below deck at side, in metres (but is not to be taken as less than D/2),
D = moulded depth, in metres.

The section modulus of hopper side stiffeners arranged longitudinally is to be obtained as above, but using a factor,

$$\frac{1,1\ (h^1+0,61)}{H}$$

where h^1 = distance of longitudinal stiffener below overflow, in metres (but is not to be taken as less than H/4),
H = height of overflow above moulded base line, in metres.

3621 The section modulus of transverses supporting longitudinal side frames or hopper side stiffeners is not to be less than:—

$\frac{I}{y} = C_3 \times l^2 \times s \times h$ cm.^{3} for shell transverses, and

$\frac{I}{y} = C_4 \times l^2 \times s \times h^1$ cm.^{3} for bulkhead transverses

where l = span of transverse, in metres, measured to mid-point of end bracket,

s = spacing of transverses, in metres,

h = head from mid-point of span to deck at side, in metres,

h^1 = head from mid-point of span to overflow, in metres,

C_3 = 9,989 for restricted service and 10,845 for unrestricted service,

C_4 = 10,845 for restricted service and 11,862 for unrestricted service.

The depth of the transverse is not to be less than $2\frac{1}{2}$ times the depth of the slot for the longitudinal.

3622 The thickness of the hopper side plating is not to be less than that required for the side shell plating, corrected as necessary for the spacing of the transverse or longitudinal stiffeners. It is recommended that the thickness of the lower strake be increased.

3623 In hoppers having no centre line box girder the strake of bottom shell plating adjacent to the hopper opening should not be less in thickness than required for a garboard strake.

3624 Continuity of strength is to be maintained at the ends of the hopper. Hopper side plating and other longitudinal members are to be suitably scarphed into the fore and aft structure. Increased topside plating in way of hopper is to be extended well forward and aft of the hopper ends.

3625 The bulkheads at the ends of hoppers are to be as required for the boundary bulkheads of deep tanks (D 19), the head being taken to the overflow.

3626 The sides of the hopper are to be connected at bottom and deck level by substantial cross-members at suitable intervals. These are to be in line with transverse bulkheads or suitable webs inside the buoyancy spaces and centre line box girder if fitted. Where a centre line box girder is fitted it should be of ample strength with suitable arrangements for resisting docking stresses. The cross-members at the bottom of the hopper should be of substantial construction to carry the loads imposed on them when the ship is placed in drydock or when the hopper is fully loaded. If a gangway is fitted above the hopper carrying the supports of bottom doors, the cross-members at deck level should be of ample strength to carry the loads imposed on them by this gangway and the weight of spoil supported.

Decks

3627 In way of the hopper the deck thickness is to be such as to satisfy the requirements of 3605 and 3606.

3628 Clear of the hopper the scantlings of the strength deck are to be determined from D 11 and Table 18 and associated notes, but the sectional area required may be reduced by 10 per cent except for unrestricted service.

3629 The corners of the hopper opening are to be well rounded, and doublings or plating of increased thickness need not be fitted except for unrestricted service.

3630 Where the seams and butts of the shell plating and deck are welded, steel of Grade D (*see* P 2, Table II) will generally be required for the following parts of the structure when the thickness exceeds 20,5 mm:—

Sheerstrake, stringer plate, deck plating, bottom shell plating and heavy plates at corners of hopper openings in shell and deck.

Beams and Deck Longitudinals

3631 The scantlings of the upper deck beams or longitudinals are to be determined from Tables 24 and 26 and associated notes, except that clear of the hopper the value of K may be taken as 1,00 irrespective of the value of $\frac{d}{D}$. Forward of 0,12L the Table factor K is to be applied (irrespective of draught) where the service is unrestricted.

Equipment

3632 The equipment number is to be calculated in accordance with the provisions of D 3303.

3633 The equipment for the figure 1 may be one grade below the requirements of Table 53.

The equipment for the class A1 will be specially considered.

Other Items

3634 Additional strengthening is to be fitted in way of ladder gallows and dredging machinery.

3635 Access to the hopper keelson space is to be provided by means of watertight manholes or watertight doors capable of being operated from both sides.

3636 The hopper keelson space is to be adequately ventilated.

3637 It is recommended that no part of the structure in way of the hopper and the hopper side tanks shall have a thickness less than $6,6+\frac{L}{36}$ millimetres, where L = length of ship, in metres, or 8,5 mm. whichever is the greater.

Section 37

BULK CARRIERS

General Design

3701 For the purpose of this Section a Bulk Carrier is a single deck ship exceeding 122 metres in length with machinery aft.

Attention should be given to the amount and distribution of water ballast. It has been found that satisfactory service has been obtained when the draught forward is not less than 0,027L and the longitudinal radius of gyration of the ballasted ship is about 0,25L.

3702 The preceding Sections of this Chapter apply to Bulk Carriers except as amended and amplified in the following.

Class Notations

3703 When one of the following class notations is desired:—

"Strengthened for Heavy Cargoes",
"Strengthened for Heavy Cargoes—Specified holds may be empty",
"Strengthened for Ore Cargoes",
"Strengthened for Ore Cargoes—Alternate (or specified) holds may be empty",

the relevant additional requirements of this Section are to be complied with.

When a class notation including "Oil Cargoes" is required, the requirements of this Section appropriate to the class 100A1 "Strengthened for Ore Cargoes" are to be applied, together with the relevant requirements of D 40 to D 53 inclusive and D 57.

3704 Where a reference to Oil Cargoes is made in the class (*see* 3703) the design is to be such that all holds are to be full except such holds as have been approved for the partially full condition or for being empty.

In holds intended to be partially full, longitudinal bulkheads are to be fitted and the transverse bulkheads strengthened.

A hold can be considered full when the oil level is above the upper knuckle of the topside tanks.

Longitudinal Strength

3705 The required section modulus at deck and keel for the various class notations is to be determined with reference to a basic modulus M.

$$M = k\,B\,(C_b+0,70)\times 10^5 \text{ cm.}^3$$

where k is to be determined from Table A,

C_b is the moulded block coefficient at a draught of 0,06L,

B is the moulded breadth, in metres.

TABLE A

LENGTH	k	LENGTH	k
Metres		Metres	
120	1,476	185	3,830
125	1,606	190	4,074
130	1,744	195	4,329
135	1,891	200	4,594
140	2,046	205	4,868
145	2,210	210	5,150
150	2,382	215	5,440
155	2,563	220	5,739
160	2,752	225	6,047
165	2,950	230	6,364
170	3,157	235	6,690
175	3,372	240	7,025
180	3,596	245	7,369

3706 The basic modulus for the class 100A1 or for the various class notations is given in Table B and Notes which also gives the maximum permissible still water bending moment (in the loaded condition) allowed in association with this modulus.

TABLE B

CLASS	BASIC $I_{/y}$		PERMISSIBLE STILL WATER BENDING MOMENT
	KEEL	DECK	
	cm.^{3}	cm.^{3}	Tonnes metres.
100A1 Strengthened for Ore Cargoes (See Note 1)	M (See Note 2)	0,93M	$5,12 \times M \times 10^{-3}$ (See Notes)
100A1 or 100A1 Strengthened for Heavy Cargoes... (See Note 1)	0,90M	0,90M	$6,3\times 0,90M\times 10^{-3}$

NOTES TO TABLE B

1. The assignment of a class notation that alternate or defined holds may be empty does not affect the basic section modulus.

2. With the notation "Strengthened for Ore Cargoes" the keel modulus may be 0,93M if the still water bending moment in the loaded condition (homogeneous in all holds or defined holds) is hogging. If the sagging stress at the keel in the loaded condition is less than 5,12 kg. per mm.^{2} the required modulus may be obtained by interpolation between:—

Sagging Stress at Keel	Required Keel Modulus
5,12	M
Nil	0,93M

The permissible still water bending moment is then:—

$5{,}12 \times 10^{-3} \times$ required keel modulus

3. If the actual still water bending moment exceeds the permissible the required section modulus at the keel becomes:—

$$\frac{I}{y} = \frac{M_1 + \frac{2 \times \text{actual S.W.B.M.}}{f \times 10^{-3}}}{3} \text{ cm.}^3$$

where M_1 is the required modulus at keel as obtained from Table B and Note 2,

f is 5,12 for the notation "Strengthened for Ore Cargoes", or
6,3 for the class 100A1 or for the notation "Strengthened for Heavy Cargoes".

The section modulus at the deck should be increased in the same proportion as the keel modulus.

4. The permissible still water bending moment in the ballast condition is:—

$6{,}3 \times M_1 \times 10^{-3}$ tonnes metres

for all bulk carriers.

If the actual still water bending moment exceeds this value the section modulus is not to be less than:—

$$\frac{I}{y} = 0{,}30M + \frac{\text{actual S.W.B.M.}}{9{,}45 \times 10^{-3}} \text{ cm.}^3$$

3707 When a notation is desired permitting certain holds to be empty the maximum still water bending moment may not occur at amidships and shearing force and bending moment curves are to be submitted. In these cases the approved loading must be incorporated in the Trim and Stability Booklet issued to the ship.

3708 All continuous longitudinal material is to be included in the calculation of the inertia of the section and the lever "y" is to be measured from the neutral axis to the top of keel and to the moulded deck line at side. For requirements with continuous coamings *see* 3709.

3709 Where continuous hatch coamings are arranged 80 per cent of the area of the continuous hatch coamings may be included in the calculation of the section modulus and the lever "y" is to be measured

(*a*) to the moulded deck line at side amidships

(*b*) to a point a distance above the moulded deck line at side amidships equal to the height of the hatch coaming above the deck.

The modulus with "y" measured as in (*a*) is to be 5 per cent greater than required by 3706 and with "y" measured as in (*b*) the modulus may be 10 per cent less than required by 3706.

Extent of Midship Scantlings

3710 The midship scantlings are to extend over the following lengths each side of midships:—

	AFT			FORWARD		
	H.C.	O.	Alt.	H.C.	O.	Alt.
Bottom	0,2L	0,25L	0,25L	0,2L	0,2L	0,25L
Side	0,2L	0,25L	0,25L	0,2L	0,25L	0,25L
Sheerstrake	0,2L	0,25L	0,25L	0,2L	0,2L	0,25L
Deck	0,2L	0,25L	0,25L	0,2L	0,2L	0,25L
Centre girder and tank top	0,2L	0,25L	0,25L	0,2L	0,2L	0,25L

H.C.—Strengthened for Heavy Cargoes (or the class 100A1 without special notation).

O. —Strengthened for Ore Cargoes.

Alt. —Strengthened for Heavy (or Ore) Cargoes—Specified holds may be empty.

Grades of Steel

3711 Where the thickness of plating exceeds 20,5 mm. and the seams (other than those covered by 3712) and butts are welded, steels of grade D (*see* P 2, Table II) will generally be required for the following parts of the structure:—

(*a*) Sheerstrake, strength deck stringer and plating, top strake of the topside tank, deck longitudinals of the slab type where cut from plates and through brackets for deck longitudinals from 0,2L aft of amidships to 0,2L forward of amidships, but at least 3 metres forward of the bridge front. Where a notation is desired that certain holds may be empty, the limits are to be 0,25L.

Sheerstrake and strength deck stringer and plating in way of poop front.

Any stringer, or sheerstrake plating outside the above limits of the midship portion which is above 25,5 mm. in thickness.

Plating at corners of openings, irrespective of position, if exceeding 20,5 mm. in thickness.

(*b*) Bottom shell plating to upper turn of bilge, bottom longitudinals of the slab type cut from plates and through brackets of bottom longitudinals from 0,15L aft of amidships to 0,15L forward of amidships where the length is 152,4 metres and below, and from 0,25L aft of amidships to 0,2L forward of amidships where the length is 213,4 metres and above with intermediate values obtained by interpolation. Where a notation is desired that certain holds may be empty the limits are to be 0,25L. Where the bottom plating is required to be of steel of grade D, the keel plate is also to be of the same grade.

3712 Strakes of grade E steel are to be arranged as follows:—

LENGTH L		GRADE E STRAKES
OVER	NOT EXCEEDING	
Metres	Metres	
167,6	198,1	Sheerstrake
198,1		Sheerstrake Bilge Strake

The grade E strakes are to extend between 0,2L aft and 0,2L forward except that when a notation is desired that certain holds may be empty the extent is to be 0,25L aft and forward.

The breadth of each strake is not to be less than 1525 mm. except that the bilge strake shall not be less than 1830 mm.

The use of riveted seams as an alternative to strakes of grade E steel will be specially considered.

3713 For scantlings and arrangements if higher tensile steel is used *see* D 65, D 66 and D 67.

Double Bottom Structure

3714 Paragraphs 3715 to 3723 do not apply where the class desired is 100A1 without a special notation; the requirements of D 5 are then applicable.

3715 The bottom structure is to be framed longitudinally. In the forward 0,25L the requirements of D 806 are to be complied with where these are in excess of those given below.

3716 The basic arrangements of floors and longitudinals for the various class notations are as given in Table C, but alternative arrangements will be specially considered.

3717 The thickness of plate floors and plate longitudinals are to be those given in Table 6 Col. 10 and Col. 12 respectively, increased by the appropriate percentages given in Table C.

3718 If the bottom longitudinals are rolled sections their section modulus is not to be less than that derived from Table 10 and associated notes. Where the length L exceeds 150 metres the value derived from the Table for a length of 150 metres is to be multiplied by $\frac{L}{150}$.

3719 If the inner bottom longitudinals are rolled sections their section modulus is not to be less than:—

$$\frac{I}{y} = \frac{S^2 \times s \times H}{C} \text{ cm.}^3$$

where S is the span, in metres,

s is the spacing of the longitudinals, in mm,

H is the height from tank top to deck at side amidships, in metres,

C is 77,25 for the notation "Strengthened for Heavy Cargoes",

61,45 for the notation "Strengthened for Ore Cargoes",

$$37{,}30 \times \frac{\text{cargo stowage rate (cubic metres/1000 kg) of specified holds}}{0{,}418}$$

(but not to exceed 61,45) for the notation "Strengthened for Ore (or Heavy) Cargoes—specified holds may be empty".

"Stowage rate" is the cubic capacity of holds divided by the cargo deadweight or, in specific cases, is the cubic capacity of a particular hold divided by the weight of cargo stowed therein.

Where plate longitudinals are fitted alternately with rolled sections, but are not required by Table C, the required modulus of the rolled sections may be reduced by 10 per cent.

TABLE C

ITEM	NOTATION		
	H.C.	O.	Alt.
Plate floors—number	On alternates	On alternates	On alternates
,, ,, thickness	+10% if longitudinals rolled sections	+10%	+10%
Longitudinals—type	Rolled sections permitted	Rolled sections permitted	Plate longitudinals and rolled sections alternately
Thickness of plate longitudinals (if fitted) and arrangement of openings therein	+15% if large openings. No increase if only manholes	+10% and only manholes	+10% and only manholes

H.C.—Strengthened for Heavy Cargoes
O. —Strengthened for Ore Cargoes.
Alt. —Strengthened for Heavy (or Ore) Cargoes—Specified holds may be empty.

3720 If longitudinals are fitted to the sloping tank top forming a hopper side tank their section modulus is not to be less than required by 3719 with H measured from the centre of the sloping portion.

3721 The thickness of the inner bottom plating is to be increased 5 mm. above the requirements of Table 6 or alternatively double ceiling is to be fitted.

3722 The height of centre girder should not be less than given by Table 6 and associated notes but may be required to be increased so that the section modulus of the girder formed by a floor in association with shell and tank top plating of width equal to the floor spacing is not less than given by:—

$$\frac{I}{y} = C \times S^2 \times s \times D \text{ cm.}^3$$

where S is (breadth of level tank top + 1,52) metres,
s is spacing of floors, in metres,
D is depth of ship, in metres,
C is 4,55 for the notation "Strengthened for Heavy Cargoes",
4,75 for the notations "Strengthened for Ore Cargoes" or "Strengthened for Heavy Cargoes—specified holds may be empty",
4,95 for the notation "Strengthened for Ore Cargoes—specified holds may be empty".

3723 The number of side girders is not to be less than required by D 503.

Bottom Shell

3724 The thickness of the bottom shell amidships to upper turn of bilge is to be that necessary to give the required section modulus but is not to be less than:—

$$\left(\frac{L}{12}+4\right)-0{,}01\ (915-s) \text{ mm.}$$

where L is the length, in metres,
s is the spacing of longitudinals, in mm.

The breadth and thickness of the keel plate are to be in accordance with Table 14, Note 1.

Side Shell

3725 The thickness of the side shell plating amidships is not to be less than:—

$$9{,}15(L+380)\ (d+9{,}145)\ (s+1015)\times 10^{-7} \text{ mm.}$$

where L is the length, in metres, (but need not be taken as greater than 228,6),
d is moulded draught, in metres,
s is the spacing of frames or longitudinals, in mm.

If the shear force diagram (*see* 3707) shows that the shear stress exceeds 5,9 kg. per mm.^{2} the shell is to be

stiffened by intermediate frames or increased in thickness in way of the excessive shear stress. If the shear stress exceeds 7,88 kg. per mm.^{2} special reinforcement will be required. The shear stress at the neutral axis is to be calculated as:—

$$\frac{100 \times F \times A\bar{y}}{I \times t} \text{ kg. per mm.}^2$$

where F = shearing force, in tonnes,

$A\bar{y}$ = first moment of area of the longitudinal material above the neutral axis, in cm.^{3},

I = moment of inertia of the transverse section, in cm.^{4},

t = 2×side shell thickness, in mm.

Side Framing

3726 The scantlings of hold frames amidships are to be obtained from Table 12 and associated notes using a value "h" measured from the double bottom tank top, or top of hopper side tank, to the underside of the topside tank or deck.

When a hopper side tank is fitted the modulus derived as above may be multiplied by $(1-\frac{x}{2D})$ where x is the height of the hopper side tank above the base, in metres, and D is the moulded depth in metres.

3727 The size, spacing and fore and aft extent of web frames for the various class notations are to be as given in Table D.

Topside Tanks

3728 The scantlings of topside tanks are not to be less than required for deep tanks. (The minimum head is to be taken as that at the half-width of the tank). The sloping plating is not to be less than required by Table 20, col. 5.

3729 Webs, transverses or wash bulkheads are to be arranged in line with the web frames required by 3727.

TABLE D

CLASS	Maximum Spacing of Webs	Fore and Aft Extent	SIZE	
			Minimum Depth	Minimum Face Area sq. cm.
100A1	8 frame spaces	0,1L fore and aft of amidships	d (*see* notes)	$\frac{d\,S}{180}$
100A1 Strengthened for Heavy Cargoes	8 frame spaces	Throughout Cargo Holds	d	$\frac{d\,S}{180}$
100A1 Strengthened for Heavy Cargoes. Specified holds may be empty	4 frame spaces	Throughout Cargo Holds	1,2d	$\frac{d\,S}{150}$
100A1 Strengthened for Ore Cargoes	8 frame spaces	Throughout Cargo Holds	1,2d	$\frac{d\,S}{150}$
100A1 Strengthened for Ore Cargoes. Alternate (or specified) holds may be empty	4 frame spaces	Throughout Cargo Holds	1,2d	$\frac{d\,S}{150}$

NOTES TO TABLE D

1. $d = 6{,}8\,S\left(\frac{L}{100}\right)^3 + 40\,S$ mm. with a minimum of 355 mm.

where S = span, in metres, measured at shell between hopper tank and topside tank but not less than $\frac{3D}{8}$,

L = length of ship, in metres,

D = moulded depth of ship, in metres.

2. The modulus of the web frame (in association with 610 mm. of plating) is not to be less than 1,5 times that of the adjacent main frame.

3. The depth of the web may require to be increased when the size of the topside tank is unusually large.

3730 When a notation is desired that certain holds may be empty a fore and aft diaphragm plate, extending from the deck to the bottom of the topside tank, is to be fitted about mid-way between the ship's side and the hatch side or alternative arrangements provided.

3731 Topside tanks are to be tested either:—

(*a*) by water testing each tank in accordance with D 1914,

(*b*) by water testing alternate tanks and air testing the remainder. The air test to be in accordance with D 5202.

Sheerstrake

3732 The radius of a rounded sheerstrake should, in general, not be less than 15 times the thickness. The radius should be made by careful cold rolling or bending. The thickness of the sheerstrake should generally not be less than 85 per cent of the stringer plate.

Bulkheads

3733 Where the class notation includes a reference to ore cargoes watertight hold bulkheads are not to be less than 10 mm. in thickness except that vertically corrugated bulkheads are not to be less than 11 mm.

Passageways

3734 Where fore-and-aft underdeck passageways are arranged at the ship's side, the after access thereto is to be by a watertight trunk led to the upper deck. Alternative arrangements to prevent the engine room being flooded in the event of a collision if the passageway doors are left open will be considered.

9th December, 1965

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ROLLED SECTIONS

The moduli given in the Tables represent the Rule standard; the scantlings given are those of the nearest acceptable section shown in Table 56

BAR KEELS AND STEMS

LENGTH L	BAR KEELS	STEMS
Metres	Millimetres	Millimetres
30	150 × 25	125 × 25
40	170 × 33	135 × 29
50	180 × 42	145 × 36
60	190 × 50	155 × 41
70	205 × 55	165 × 45
80	215 × 59	185 × 49
90	225 × 63	200 × 53
100	240 × 67	210 × 58
110	260 × 70	220 × 62
120		230 × 66
130		240 × 70
140		260 × 75
150		275 × 76
160		285 × 76
170		295 × 80
180		300 × 85
190		305 × 89
200		305 × 97

TABLE 2

STERNFRAMES WITH APERTURES

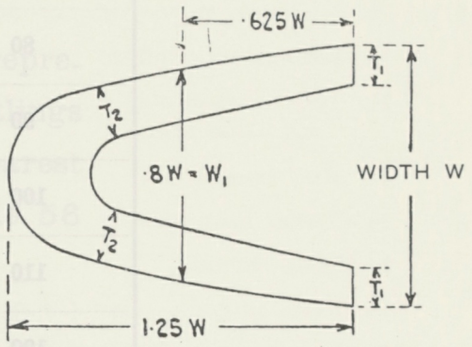
LENGTH L	WIDTH AND THICKNESS						
	SOLID		CASTING			BUILT	
	WIDTH		WIDTH	THICKNESS		WIDTH	THICKNESS
	Rectangular	Streamlined W	W	T_1	T_2	W	
1	2	3	4	5	6	7	8
Metres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
30	65						
40	80						
50	95						
60	115	150	205	19	32	255	20
70	130	170	220	24	36	270	21
80	145	190	235	28	40	285	22
90	165	210	250	31	44	300	23
100	180	225	260	33	46	320	25
110	195	240	270	36	51	335	27
120	205	250	285	38	56	350	29
130	215	260	295	41	60	370	31
140	225	270	305	44	63	385	32
150	235	280	315	45	63	400	33
160	245	285	325	47	64	420	34
170	250	290	335	49	64	435	35

NOTES.—TABLE 2

1. The dimensions given in the Table apply to both propeller post and rudder post.

2. The fore and aft dimension of the section is to be 25 per cent greater than its width as given in cols. 2, 3, 4 and 7 but is not to be less than 125 mm.

3. The width W given in cols. 3, 4 and 7 for streamlined solid, cast or built sternframes is the extreme width. The width W_1 at half the fore and aft dimension of the section is assumed to be 80 per cent of the extreme width. (See sketch.)



Where the section of sternframe adopted differs from that given above an equivalent section modulus is to be obtained.

4. The solepiece in way of the aperture is to be extended in an athwartship direction to a width 50 per cent greater than that given in col. 2 ; the vertical dimension is to be equal to the width in col. 2. If a rudder post is not fitted the scantlings of the solepiece will be specially considered.

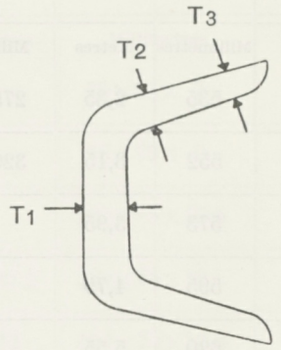
5. The boss of the propeller post is to have a finished thickness of metal round the bore equal to 60 per cent of the width given in col. 2.

6. The scantlings given in cols. 5, 6 and 8 are minima.

7. For scantlings of gudgeons *see* D 313.

STERNFRAMES OF TWIN SCREW SHIPS

LENGTH L	SOLID	CASTINGS		
	WIDTH	THICKNESS		
		T_1	T_2	T_3
Metres	Millimetres	Millimetres	Millimetres	Millimetres
40	34			
50	42			
60	50	27	23	15
70	58	30	25	17
80	66	34	27	20
90	74	39	29	23
100		44	32	25
110		49	35	28
120		54	38	30
130		60	42	33
140		65	46	35
150		71	49	37
160		77	53	40
170		84	56	42
180		91	61	44
190		98	66	46
200		105	71	47



NOTES.—TABLE 3

1. Fore and aft dimensions of solid sternposts are to be three times the width.

2. The side flanges of cast steel sternposts are to have dimensions sufficient to take the shell connection.

TABLE 4

FLOORS

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	BREADTH B METRES							
			5	6	7	8	9	10	11	12
Metres	Millimetres	Metres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millim
3	535	2,35	275×6	295×6,5	320×6,5	355×7	385×7	405×7,5		
4	552	3,15	320×6,5	340×6,5	360×7	395×7,5	440×8	480×8,5		
5	573	3,95				440×7,5	480×8	520×8,5	565×9	605×
6	595	4,75						565×9	605×9	645×
7	620	5,55							645×9,5	690×
8	662	6,35								730×
9	705	7,15								

NOTES.—TABLE 4

1. **Corrections.**

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b depth of floors is to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of 12,5 mm. per 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in the Table the thickness of the floors and of the reversed

INGLE BOTTOMS

BREADTH B METRES								REVERSED FRAMES	DEPTH D
13	14	15	16	17	18	19	20		
Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Metres
								75×65× 7	3
								75×75× 9	4
								100×75×10,5	5
80×10	730×10	800×10	850×10,5	880×11	935×11	935×11,5	980×11,5	130×75×12	6
25×10	770×10,5	815×10,5	875×11	905×11,5	960×11,5	960×12	1010×12	150×75×13,5	7
65×10,5	815×10,5	855×10,5	915×11	950×11,5	990×12	1040×12	1040×12,5	150×75×14,5	8
	850×10,5	885×11	915×11,5	950×12	1030×12	1040×12,5	1080×12,5	150×90×18,5	9

NOTES.—TABLE 4 (*concluded*)

frames is to be $\begin{matrix}\text{increased}\\ \text{reduced}\end{matrix}$ at the rate of 0,5 mm. and 1 mm. respectively for every 100 mm. of difference.

2. **Increases in machinery spaces.**—In the engine room the floors are to be increased 1 mm. and in the boiler room the floors and the reversed frames are to be increased 2,5 mm. beyond the thicknesses given in the Table.

TABLE 5

KEELSONS IN SINGLE BOTTOMS

LENGTH L	CENTRE KEELSONS						SIDE KEELSONS	
	PLATE KEEL ANGLES		DOUBLE TOP ANGLES	THICKNESS OF VERTICAL PLATES AND FOUNDATION PLATES IF FITTED		BREADTH OF FOUNDATION PLATES IF FITTED	SINGLE TOP ANGLE	THICKNESS OF INTERCOSTAL PLATE
	FOR 0,4L AMIDSHIPS	THICKNESS FOR 0,1L FROM ENDS	THROUGHOUT	FOR 0,4L AMIDSHIPS	THICKNESS FOR 0,1L FROM ENDS			
1	2	3	4	5	6	7	8	9
Metres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
30	75×75× 6,5	6,5	75×75× 6,5	7,5	6,5	250	100×75× 7,0	6,0
40	75×75× 8,0	7,5	90×75× 7,5	8,5	7,0	275	100×75× 7,5	6,5
50	75×75× 8,5	8,0	100×75× 8,0	9,5	7,5	295	100×75× 8,0	7,0
60	90×90× 9,5	9,0	110×75× 8,0	10,0	8,5	325	130×75× 8,5	8,0
70	90×90×10,5	10,0	130×75× 8,5	10,5	9,0	370	130×75× 8,5	8,5
80	90×90×10,5	10,0	130×75× 9,5	11,0	9,0	410	130×75× 9,0	9,0
90	90×90×11,0	10,5	150×75×10,0	11,5	9,5	450	130×75×10,0	9,5
100	90×90×11,5	11,0	160×90×10,5	12,0	10,0	490	130×75×11,0	10,0

KEELSONS IN TUGS

LENGTH L	CENTRE KEELSON ON TOP OF FLOORS WITH BAR KEEL		SIDE KEELSON ON TOP OF FLOORS
	SINGLE CHANNEL	DOUBLE BULB ANGLES	SINGLE ANGLE
Metres	Millimetres	Millimetres	Millimetres
30	200×85×11,0	150×75× 8,0	130×100× 9,0
35	220×90×11,0	150×75× 9,5	130×100× 9,5
40	220×90×12,0	165×75× 9,5	130×100×10,0
45	240×95×13,0	165×75×10,5	130×100×10,5
50	260×95×14,0	180×75× 9,5	130×100×11,5

NOTES.—TABLE 5

In boiler rooms the thickness of the centre and side keelsons, foundation plates and angles not covered by cement is to be increased by 2,5 mm.

TABLE 6 DOUBLE BOTTOMS

LENGTH L	FRAME SPACING AMIDSHIPS	CENTRE GIRDER					MARGIN PLATE		FLOOR PLATES, GIRDERS AND BRACKETS INSIDE TANK		
				THICKNESS			THICKNESS		THICKNESS		
		BASIC DRAUGHT d_b	HEIGHT ABOVE BASE LINE	FOR 0,4L AMIDSHIPS	FOR 0,1L FROM ENDS	IN BOILER ROOM	IN HOLDS AND ENGINE ROOM	IN BOILER ROOM	FLOORS IN HOLDS AND ENGINE ROOM. SIDE GIRDERS IN ENGINE ROOM	FLOORS AND SIDE GIRDERS IN BOILER ROOM	SI GIRI I HOI
1	2	3	4	5	6	7	8	9	10	11	1
Metres	Millimetres	Metres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millin
40	560	2,4	665	8,0	6,5	10,5	7,0	9,5	6,5	9,0	6
50	580	3,0	665	9,0	7,5	11,5	8,0	10,5	7,0	9,5	7
60	600	3,6	710	10,0	8,5	12,5	9,0	11,5	7,5	10,0	7
70	620	4,2	750	10,5	9,0	13,0	9,5	12,0	8,0	10,5	7
80	640	4,8	790	11,0	9,0	13,5	10,0	12,5	8,0	10,5	7
90	660	5,4	845	11,5	9,5	14,0	10,5	13,0	8,5	11,0	8
100	680	6,0	915	12,0	10,0	14,5	11,0	13,5	9,0	11,5	8
110	700	6,6	970	12,5	10,5	14,5	11,5	14,0	9,5	12,0	8
120	720	7,2	1050	13,0	11,0	15,0	12,5	14,5	10,0	12,5	9
130	740	7,8	1110	13,5	11,5	15,5	13,0	15,0	10,5	13,0	9
140	760	8,4	1175	13,5	11,5	15,5	13,5	15,5	10,5	13,0	9
150	780	9,0	1235	14,0	12,0	16,0	14,0	16,0	11,0	13,5	10
160	800	9,15	1250	14,5	12,5	16,5	15,0	16,5	11,5	14,0	10
170	820	9,15	1290	15,0	13,0	17,0	16,0	17,5	12,0	14,0	11
180	840	9,15	1310	15,5	13,5	17,0	16,5	18,0	12,5	14,5	11
190	860	9,15	1325	16,0	14,0	17,5	17,0	18,5	13,0	14,5	11
200	880	9,15	1350	16,5	14,5	17,5	18,0	19,0	13,5	15,0	12

NOTES.—TABLE 6

1. Corrections.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b the height of the centre girder to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of 12,5 mm. for each 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships is $\frac{\text{greater}}{\text{less}}$ than that given in col. 2 the thickness of the floor and bracket plates, margin plate and inner bottom plating to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of 0,5 mm. for every 100 mm. of difference.

If, in transversely framed ships, the spacing amidships exceeds the Table spacing by 100 mm. or more the increase required will be specially considered.

The thickness of the inner bottom plating in the engine and boiler rooms and of the middle line strake throughout should not be corrected for frame spacing but is not to be less than the thickness derived from col. 16 after correction.

The thickness of watertight floors is to be 2 mm. greater than the thickness given in col. 10, but need not exceed 13,5 mm.

INNER BOTTOM PLATING							ANGLE CONNECTIONS					
MIDDLE LINE STRAKE EXCEPT IN BOILER ROOM		REMAINDER					ANGLES CONNECTING CENTRE GIRDER TO FLAT PLATE KEEL		ANGLES CONNECTING CENTRE GIRDER TO INNER BOTTOM			
	THICKNESS											
			IN HOLDS									
READTH	FOR 0,4L AMIDSHIPS	FOR 0,1L FROM ENDS	FOR 0,4L AMIDSHIPS	FOR 0,1L FROM ENDS	IN ENGINE ROOM	IN BOILER ROOM INCLUDING MIDDLE LINE STRAKE	FOR 0,4L AMIDSHIPS	THICKNESS FOR 0,1L FROM ENDS	FOR 0,4L AMIDSHIPS	THICKNESS FOR 0,1L FROM ENDS	ANGLES CONNECTING MARGIN PLATE TO SHELL PLATING	LENGTH L
13	14	15	16	17	18	19	20	21	22	23	24	25
illimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Metres
960	7,0	6,5	6,5	6,5	7,5	10,5	75× 75× 8,0	7,5	65×65× 7,0	7,0	75×75× 7,5	**40**
1000	7,5	7,0	7,0	7,0	8,0	11,0	75× 75× 9,0	8,5	75×75× 7,5	7,5	75×75× 8,0	**50**
1040	8,5	8,0	8,0	7,5	9,0	12,0	75× 75×10,0	9,5	75×75× 8,0	8,0	75×75× 9,0	**60**
1080	9,5	8,5	8,5	8,0	10,0	12,5	90× 90×10,5	10,0	75×75× 9,0	8,5	75×75×10,0	**70**
1120	10,0	8,5	8,5	8,0	10,0	13,0	90× 90×11,0	10,5	75×75× 9,5	9,0	75×75×10,5	**80**
1160	10,5	9,0	9,0	8,5	10,5	13,0	90× 90×11,0	10,5	75×75×10,0	9,5	90×90×11,5	**90**
1205	11,5	9,5	9,5	8,5	11,5	13,5	90× 90×11,5	11,0	75×75×10,5	10,0	90×90×11,5	**100**
1245	12,0	10,0	10,0	9,0	12,0	14,0	90× 90×12,0	11,5	75×75×11,0	10,5	90×90×12,0	**110**
1285	12,5	10,5	10,5	9,5	12,5	14,0	90× 90×12,5	12,0	90×90×11,5	10,5	90×90×12,5	**120**
1330	13,0	11,0	11,0	10,0	13,0	14,5	130×130×13,0	12,5	90×90×11,5	10,5	90×90×13,0	**130**
1370	13,0	11,0	11,0	10,0	13,0	15,0	130×130×13,5	12,5	90×90×12,0	11,0	90×90×13,5	**140**
1410	14,0	12,0	12,0	11,0	14,0	15,0	130×130×14,0	13,0	90×90×12,5	11,5	90×90×14,0	**150**
1455	14,5	12,5	12,5	11,5	14,5	15,5	130×130×15,0	13,5	90×90×13,5	12,0	90×90×14,0	**160**
1495	15,0	13,0	13,0	12,0	15,0	16,0	130×130×15,5	14,0	90×90×14,0	12,5	90×90×14,0	**170**
1535	16,0	14,0	13,5	12,5	16,0	16,5	130×130×16,0	14,5	90×90×14,0	13,0	90×90×14,0	**180**
1580	16,5	14,5	14,0	13,0	16,5	17,0	130×130×17,0	15,5	90×90×14,0	13,5	90×90×14,0	**190**
1640	17,0	15,0	14,5	13,5	17,0	17,0	130×130×17,5	16,0	90×90×14,0	13,5	90×90×14,0	**200**

NOTES.—TABLE 6 *(concluded)*

2. **Depth of margin plate** is not to be less than 80 per cent of the depth of centre girder corrected by note 1, where the length of the ship does not exceed 105 metres, or 85 per cent where the length is 125 metres and above, with intermediate values in proportion. At the after end the depth may be reduced to 85 per cent of the depth amidships.

3. **Thickness of connecting angles not given in Table.**—The thickness of the vertical angles connecting intercostal girders to floors is not to be less than that of the intercostal plate. The thickness of the frames, reversed frames and other connecting angles is not to be less than the thickness of the floors.

4. **Width of faying flanges.**—For width of faying flanges for all angles, unless specified in the Table, *see* D 3202.

5. **In boiler rooms** angles not covered by cement are to be increased by 2,5 mm. in thickness.

6. **Oil fuel.**—For thickness of inner bottom plating when oil fuel is carried in the double bottom, *see* D 2021.

TABLE 7

BRACKET FLOORS

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS PER 0,3 METRE DIFFERENCE BETWEEN d and d_b*		UNSUPPORTED SPAN METRES 1,00	1,25	1,50	1,75	2,00	2,25	2,50	
Metres	Millimetres	Metres	Per cent		MILLIMETRES *Modulus—Centimetres³*							
4	552	3,18	*9,4*	ANGLES	100×75× 9,5 *34,2*	120×75×10 *49,1*	140×75× 9 *59,2*					
5	573	4,02	*7,6*	ANGLES	120×75× 9 *44,6*	*63,9*	150×75×10,5 *77,4*	*84,8*	*92,4*	150×75× 8,5 *107*	165×75× 8,5 *132*	BULB ANGLES
6	595	4,75	*6,3*	ANGLES	130×75× 9,5 *55,0*	150×75×10,5 *78,8*	*96,2*	*105*	150×75× 9,0 *114*	165×75× 8,5 *132*	180×75× 8,5 *163*	BULB ANGLES
7	620	5,58	*5,4*	ANGLES	140×75×10,5 *67,8*	*96,5*	150×75× 9,5 *118*	150×75×10,5 *128*	165×75× 9,0 *140*	180×75× 8,5 *162*	180×90×11,5 *197*	BULB ANGLES
8	662	6,42	*4,7*	ANGLES	150×75×11 *81,8*	150×75× 9,5 *117*	165×75× 9,5 *142*	165×75×10,5 *155*	180×90× 9,0 *171*	180×90×11,5 *198*	200×90×10,5 *235*	BULB ANGLES
9	705	7,15	*4,2*	BULB ANGLES	*98,1*	165×75× 9,0 *139*	180×90× 9,0 *170*	180×90×10,5 *186*	180×90×11,5 *204*	200×90×11,0 *239*	*284*	BULB ANGLES
10	748	7,98	*3,8*	BULB ANGLES	150×75× 9,5 *116*	180×75× 8,5 *165*	180×90×11,5 *200*	*219*	200×90×11,0 *242*	*280*	230×90×12,0 *340*	BULB ANGLES
11	790	8,82	*3,4*	BULB ANGLES	165×75× 8,5 *135*	180×90×11 *192*	200×90×10,5 *233*	200×90×12 *258*	*282*	230×90×11,0 *322*	250×90×11,0 *397*	BULB ANGLES
12	830	9,15	*3,2*	BULB ANGLES	*148*	*210*	200×90×12 *256*	*286*	*312*	230×90×12,5 *349*	250×90×12,5 *435*	BULB ANGLES
13	870	9,15	*3,2*	BULB ANGLES	*156*	*221*	200×90×13 *268*	*302*	230×90×11,0 *328*	230×90×13,5 *367*	250×90×13,5 *459*	BULB ANGLES
14	912	9,15	*3,2*	BULB ANGLES	*164*	200×90×10,5 *232*	*281*	*316*	230×90×12,0 *344*	*384*	*481*	BULB ANGLES
15	955	9,15	*3,2*	BULB ANGLES	180×90× 9,5 *172*	200×90×11 *242*	*294*	230×90×11,5 *332*	230×90×13,0 *361*	250×90×11,0 *401*	*499*	BULB ANGLES

NOTES.—TABLE 7

1. **Scantlings.**—The bottom frames are to have scantlings determined from the Table ; the modulus of the reversed frames may be 85 per cent of that of the bottom frames corrected as required below. For width of faying flanges *see* D 3202.

2. **Correction to modulus of frames.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In boiler rooms**, frames, reversed frames, struts and angle connections are to be increased by 2,5 mm. in thickness.

4. Particulars of sections and moduli are given in Table 56.

DETAILS OF BRACKET FLOORS

DEPTH OF FRAME		RIVETS IN BRACKETS		RIVETS IN EACH END OF VERTICAL BAR ON INTERCOSTAL GIRDER		VERTICAL STRUTS BETWEEN INTERCOSTAL GIRDER AND CENTRE LINE OR MARGIN PLATE	RIVETS IN EACH END OF VERTICAL STRUTS	
		NUMBER	DIAMETER	NUMBER	DIAMETER		NUMBER	DIAMETER
1		2	3	4	5	6	7	8
Millimetres			Millimetres		Millimetres	Millimetres		Millimetres
90 and 100	ANGLES	4	16	2	16	150×75×8,5	2	16
130	ANGLES	5	16	2	16	150×75×9,0	3	16
150	ANGLES	5	19	2	19	200×85×85×11,0	4	19
130 and 140	BULB ANGLES	5	19	2	19	200×85×85×11,0	4	19
150	BULB ANGLES	6	19	2	19	200×85×85×11,0	4	22
180	BULB ANGLES	7	19	3	19	200×85×85×11,0	4	22
200	BULB ANGLES	8	19	4	19	220×90×90×11,0	5	22
230	BULB ANGLES	8	22	4	22	240×95×95×12,0	6	22
250 and above	BULB ANGLES	9	22	4	22	260×95×95×12,0	6	22

CHANNELS

NOTES.—TABLE 8

1. **In boiler rooms** struts are to be increased by 2,5 mm. in thickness.

2. For scantlings of welded vertical struts *see* D 515.

TABLE 9 STIFFENERS TO WATERTIGHT FLOORS

Spaced 760 millimetres apart

DEPTH OF CENTRE GIRDER		HEIGHT OF OVERFLOW ABOVE INNER BOTTOM METRES						
		6,0	7,5	9,0	10,5	12,0	13,5	15,0
Millimetres		Millimetres *Modulus—Centimetres³*						
900	ANGLES	90×75× 7,5 *21,6*	90×75× 9,5 *27,4*	100×75× 8,5 *31,0*	100×75×10,5 *36,5*	100×75×11,5 *40,5*	120×75× 9,5 *46,8*	120×75×10,5 *51,5*
1100	ANGLES	100×75× 9,5 *33,3*	120×75× 8,0 *40,3*	120×75× 9,5 *47,0*	130×75× 9,5 *55,0*	140×75× 9,5 *63,0*	140×75×10,5 *70,5*	150×75×10,5 *79,2*
1300	ANGLES	120×75× 9,5 *48,1*	130×75×10,5 *58,7*	140×75×10,5 *68,6*	150×75×11,0 *82,0*	*90,0*	150×75× 8,0 *104*	150×75× 9,0 *113*
1500	ANGLES	140×75× 9,5 *61,9*	150×75×10,5 *78,0*	*91,0*	150×75× 8,5 *111*	150×75×10,0 *121*	165×75× 8,5 *133*	165×75×10,0 *146*
1700	ANGLES	150×75×11,0 *83,0*	*97,5*	150×75× 9,5 *118*	165×75× 9,0 *140*	165×75×10,5 *155*	180×75× 9,5 *175*	180×75×11,0 *194*
1900	BULB ANGLES	*100*	150×75×10,5 *126*	165×75×10,0 *147*	180×75× 9,0 *172*	180×75×11,0 *190*	200×75× 9,0 *210*	200×75×10,5 *239*

BULB ANGLES

NOTES.—TABLE 9

1. **In boiler rooms** stiffeners are to be increased by 2,5 mm. in thickness.

2. Particulars of sections and moduli are given in Table 56.

NOTES.—TABLE 10

1. **Scantlings.**—The bottom longitudinals are to have scantlings determined from the Table; the modulus of the inner bottom longitudinals may be 85 per cent of that of the bottom longitudinals corrected as required below. For width of faying flanges *see* D 3202.

2. **Corrections to modulus of bottom longitudinals.**

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, modulus to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentage given in the Table per 0,3 metre of difference.

FOR SPACING OF LONGITUDINALS.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In boiler rooms,** longitudinals, struts and angle connections are to be increased by 2,5 mm. in thickness.

4. Particulars of sections and moduli are given in Table 56.

LENGTH L	SPACING OF LONGITUDINALS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS PER 0,3 METRE DIFFERENCE BETWEEN d and d_b	UNSUPPORTED SPAN METRES 1,25	1,5	1,75	2,0	2,25	2,5
Metres	Millimetres	Metres	Per cent	MILLIMETRES Modulus—Centimetres³					
30	665	1,80	*16,9*	100×75×10 *35,6*	120×75×8,5 *42,4*	130×75× 8 *46,4*	140×75× 8 *53,4*	140×75× 9 *59,6*	150×75× 9 *67,7*
35	675	2,10	*14,6*	120×75× 8,5 *42,4*	130×75× 8,5 *49,2*	140×75× 8,5 *56,5*	140×75× 9,5 *62,7*	150×75× 9,5 *71,3*	150×75×10,5 *78,5*
40	685	2,40	*12,8*	130×75× 8,5 *49,2*	140×75× 8,5 *56,5*	140×75×10 *65,8*	150×75×10 *74,9*	150×75×11 *82,0*	150×75× 7 *97*
45	695	2,70	*11,3*	130×75× 9,5 *54,7*	140×75× 9,5 *62,7*	150×75×10 *74,9*	150×75×11 *82,0*	150×75× 7 *97*	150×75× 8 *105*
50	705	3,0	*10,2*	130×75×10,5 *59*	140×75×10,5 *70*	150×75×11 *81*	*92*	150×75× 8 *103*	150×75× 9 *115*
55	715	3,3	*9,2*	140×75×10 *66*	150×75×10,5 *79*	*92*	150×75× 8 *104*	150×75× 9,5 *116*	165×75× 8 *129*
60	725	3,6	*8,4*	150×75×10 *75*	*89*	150×75× 8 *103*	150×75× 9,5 *116*	165×75× 8 *130*	165×75× 9,5 *144*
65	735	3,9	*7,8*	150×75×11,5 *84*	*99*	150×75× 9 *114*	165×75× 8 *129*	165×75× 9,5 *144*	180×75× 8 *160*
70	745	4,2	*7,2*	*93*	150×75× 8,5 *109*	150×75×10,5 *129*	165×75× 9,5 *142*	180×75× 8 *159*	180×75× 9,5 *176*
75	755	4,5	*6,65*	150×75× 8 *103*	150×75×10 *121*	165×75× 9 *139*	180×75× 8 *156*	180×75× 9,5 *175*	180×75×11 *194*
80	765	4,8	*6,25*	150×75× 9 *112*	165×75× 8,5 *132*	165×75×10,5 *151*	180×75× 9 *171*	180×75×11 *191*	200×75× 9 *211*
85	775	5,1	*5,90*	150×75×10 *122*	165×75× 9,5 *145*	180×75× 8,5 *164*	180×75×10,5 *185*	*207*	200×75×10 *230*
90	785	5,4	*5,60*	165×75× 8,5 *134*	180×90× 8 *157*	180×90×10 *178*	180×90×11,5 *200*	200×90×10 *223*	200×90×11,5 *248*
95	795	5,7	*5,30*	165×75× 9,5 *145*	180×90× 9 *170*	180×90×11 *192*	*217*	200×90×11 *241*	200×90×12,5 *266*
100	805	6,0	*5,0*	180×90× 8 *158*	180×90×10,5 *184*	*208*	200×90×10,5 *233*	200×90×12 *259*	*286*
105	815	6,3	*4,57*	180×90× 9,5 *173*	180×90×11,5 *199*	200×90×10 *224*	200×90×11,5 *250*	*277*	*306*
110	825	6,6	*4,50*	180×90×10,5 *187*	*212*	*242*	*269*	*296*	230×90×11,5 *326*
115	835	6,9	*4,35*	180×90×11,5 *199*	200×90×10 *229*	200×90×12 *258*	*287*	*317*	230×90×12,5 *349*
120	845	7,2	*4,20*	*214*	200×90×11,5 *245*	*276*	*307*	230×90×12 *339*	*371*
125	855	7,5	*4,05*	200×90×10 *230*	200×90×12,5 *261*	*294*	230×90×11 *327*	230×90×13 *361*	*396*
130	865	7,8	*3,85*	200×90×11,5 *247*	*278*	*312*	230×90×12,5 *348*	*384*	250×90×12 *419*
135	875	8,1	*3,70*	200×90×12,5 *265*	*297*	230×90×11,5 *333*	*371*	250×90×11 *407*	250×90×13 *442*
140	885	8,4	*3,55*	*281*	*318*	230×90×12,5 *352*	*390*	250×90×12,5 *430*	*470*
145	895	8,7	*3,40*	*302*	230×90×11,5 *337*	*376*	250×90×11,5 *416*	250×90×13,5 *456*	*496*
150	905	9,0	*3,30*	*321*	230×90×13 *358*	250×90×11 *399*	250×90×12,5 *439*	*480*	*522*

ANGLES

BULB ANGLES

BULB ANGLES

For notes see previous page

TABLE 11 ATTACHMENT OF TANK SIDE BRACKE

(SEE CONTINUATION)

DEPTH D	FRAME SPACING AMIDSHIPS	HEIGHT OF TANK SIDE BRACKET ABOVE BASE	FRAME											
			90 AND 100 MM. ORDINARY ANGLE				120 AND 130 MM. ORDINARY ANGLE				150 MM. ORDINARY ANGLE			
			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE		
				ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECT
Metres	Millimetres	Millimetres	Millimetres				Millimetres				Millimetres			
4	552	870	7	5†	—	5†	7,5	5*	—	5†	7,5	5*	—	5†
5	573	1040	7	5*	—	5†	7,5	5*	—	5*	8	5*	—	5*
6	595	1205									8,5	6*	—	5*
7	620	1360												
8	662	1485												
9	705	1610												
10	748	1730												
11	790	1830												
12	830	1910												
13	870	1985												
14	912	2055												
15	955	2120												

† Rivets 16 mm. diameter * Rivets 19 mm. diameter Remainder 22 mm. diameter.

For notes see pages 106 & 107

TABLE 11
(SEE CONTINUATION)

FRAME															DEPTH D
150 AND 165 MM. BULB ANGLE				180 MM. BULB ANGLE				200 MM. BULB ANGLE				230 MM. BULB ANGLE				
ICKNESS F TANK SIDE RACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			
	ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION	
illimetres				Millimetres				Millimetres				Millimetres				Metres
8	6*	—	5*													**4**
8	6*	—	6*													**5**
8,5	6*	—	6*	8,5	6*	1*	6*	8,5	6*	2*	7*					**6**
9	6*	1*	6*	9	6*	2*	6*	9	5	2	6	9,5	6	3	7	**7**
9,5	6*	2*	6*	9,5	5	1	5	9,5	5	2	6	10	6	4	8	**8**
				10,5	6	2	6	10,5	6	3	7	10,5	7	4	8	**9**
								10,5	7	3	7	11	8	4	8	**10**
								11	7	4	8	11	8	5	8	**11**
												11,5	8	6	9	**12**
												12	8	7	9	**13**
												12	8	7	9	**14**
																15

† Rivets 16 mm. diameter * Rivets 19 mm. diameter Remainder 22 mm. diameter.

For notes see pages 106 & 107

DEPTH D	FRAME SPACING AMIDSHIPS	HEIGHT OF TANK SIDE BRACKET ABOVE BASE	FRAME											
			250 MM. BULB ANGLE				280 MM. BULB ANGLE				300 MM. BULB ANGLE			
			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE		
				ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION
Metres	Millimetres	Millimetres	Millimetres				Millimetres				Millimetres			
4	552	870												
5	573	1040												
6	595	1205												
7	620	1360	10	6	5	8								
8	662	1485	10,5	7	6	8	10,5	7	6	8	10,5	8	8	9
9	705	1610	11	8	6	9	11	8	7	9	11	9	8	10
10	748	1730	11	8	6	9	11	8	7	9	11,5	9	8	10
11	790	1830	11,5	8	6	9	11,5	9	7	10	12	9	8	10
12	830	1910	12	8	7	10	12	9	8	11	12	9	9	11
13	870	1985	12	8	8	10	12	9	9	11	12,5	10	9	11
14	912	2055	12	9	8	10	12,5	9	9	11	12,5	10	9	12
15	955	2120	12,5	9	8	10	12,5	10	9	11	12,5	11	9	12

Rivets 22 mm. diameter.

NOTES.—TABLE 11

1. **Corrections.**—If the frame spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in the Table, the thickness of the tank side brackets is to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of 0,5 mm. for every 100 mm. of difference.

2. The height of tank side brackets is to be measured at the inner edge of the frame.

TABLE 11
(CONCLUDED)

FRAME												DEPTH D
300 TO 350 MM. CHANNEL AND 320 TO 340 MM. BULB ANGLE				380 MM. CHANNEL OR BULB ANGLE				400 MM. CHANNEL				
THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			
	ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION	
Millimetres				Millimetres				Millimetres				Metres
												4
												5
												6
												7
11	9	8	10	11	9	9	12	11,5	10	9	13	8
11	10	8	10	11,5	10	9	12	12	11	9	13	9
11,5	10	8	11	11,5	10	9	12	12	11	9	13	10
12	10	8	11	12	10	9	12	12,5	11	10	13	11
12,5	10	9	11	12,5	11	10	12	13	12	11	14	12
13	11	9	12	13	11	10	13	13	12	11	14	13
13	11	9	12	13	12	10	13	13	13	11	14	14
13	12	10	12	13	13	11	13	13	14	12	14	15

Rivets 22 mm. diameter.

NOTES.—TABLE 11 (*continued*)

3. The angles connecting the tank side brackets to the margin plate are to have the same thickness as the brackets.

4. **In boiler rooms**, the tank side brackets, gussets and connecting angles are to be increased 2,5 mm. in thickness.

5. For increases in way of panting region *see* D 906.

TABLE 12

(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b		FRAMING IN PEAKS	Correction to Modulus of Main Framing per 0,3 metre difference between d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK (METRES)								
						2,4	3,0	3,6	3,9	4,2	4,5	4,8	5,1	5,4
Metres	Mm.	Metres		Millimetres Modulus—cms.³	Per cent	< Millimetres Modulus—centimetres³								
3,0	535	2,35	ANGLES	90×65× 8 *24,0*	*14,9*	90×75× 7 *21,0*	90×75× 8 *24,0*	90×75× 9,5 *28,0*	100×75× 8,5 *31,0*	100×75× 9,5 *34,0*				
3,3	540	2,60		90×65× 9,5 *28,0*	*13,9*	90×75× 8 *23,0*	90×75× 9,5 *28,0*	100×75× 9,5 *34,0*	100×75×10,5 *37,0*	120×75× 8 *41,0*				
3,6	545	2,85		100×75× 8,5 *30,0*	*12,9*	90×75× 8,5 *25,0*	100×75× 9 *32,0*	120×75× 8 *40,0*	120×75× 9 *44,0*	130×75× 8,5 *49,0*	130×75×10 *56,0*			
3,9	550	3,10		100×75×11,5 *40,0*	*12,0*			130×75× 8 *47,0*	130×75× 9 *52,0*	130×75×10 *58,0*	150×75× 9 *65,0*	150×75×10 *73,0*		
4,2	555	3,35		130×75× 9,5 *54,0*	*11,1*			130×75× 9,5 *55,0*	150×75× 8,5 *62,0*	150×75× 9,5 *68,0*	150×75×10,5 *76,0*	150×75×11,5 *84,0*	150×75×12,5 *93,0*	
4,5	565	3,60		130×75×10 *58,0*	*10,5*			150×75× 8,5 *63,0*	150×75× 9,5 *71,0*	150×75×10,5 *78,0*	150×75×12 *87,0*	140×65× 9 *95,0*	150×75× 8 *104*	150×75× *114*
4,8	570	3,85		130×75×11 *62,0*	*10,0*				150×75×11 *81,0*	150×75×12 *89,0*	150×75× 7,5 *98,0*	150×75× 8,5 *107*	150×75× 9,5 *118*	150×75× *128*
5,1	575	4,10		150×75× 9 *66,0*	*9,5*					150×75× 8 *102*	150×75× 9 *112*	150×75×10 *121*	165×75× 8,5 *132*	165×75× *144*
5,4	580	4,35		150×75× 9,5 *70,0*	*9,0*					150×75× 9,5 *115*	150×75×10,5 *126*	165×75× 9 *136*	165×75×10 *148*	180×75× *161*
5,7	590	4,55		150×75×10 *75,0*	*8,5*	150×75× 7,5 *101*	150×75× 8,5 *106*	150×75× 9,5 *115*	150×75×10 *121*	165×75× 8,5 *130*	165×75× 9,5 *140*	165×75×10,5 *151*	180×75× 9 *166*	180×75×1 *182*
6,0	595	4,75		150×75×11 *82,0*	*8,0*	150×75× 8,5 *108*	150×75× 9,5 *115*	150×75×10,5 *126*	165×75× 9 *134*	165×75×10 *145*	180×75× 8 *157*	180×75× 9,5 *171*	180×75×10,5 *187*	*205*
6,3	600	5,00	BULB ANGLES	140×65× 8 *88,0*	*7,5*	150×75× 9,5 *118*	150×75×10,5 *125*	165×75× 9 *138*	165×75×10 *147*	180×75× 8 *158*	180×75× 9,5 *173*	180×75×10,5 *188*	*205*	200×75×1 *224*
6,6	605	5,25		140×65× 9 *96,0*	*7,0*	150×75×10,5 *127*	165×75× 9 *136*	165×75×10,5 *150*	180×75× 8 *159*	180×75× 9,5 *172*	180×75×10,5 *187*	*203*	200×75× 9,5 *220*	200×75×1 *240*
6,9	615	5,50		150×75× 8 *105*	*6,6*	165×75× 9 *137*	165×75×10 *147*	180×75× 8,5 *162*	180×75× 9,5 *172*	180×75×10,5 *185*	*200*	200×75× 9,5 *217*	200×75×10,5 *235*	200×75×1 *255*
7,2	630	5,75		150×75× 9 *115*	*6,3*	165×75×10 *148*	180×75× 8 *158*	180×75× 9,5 *174*	180×75×10,5 *186*	*200*	200×75× 9 *215*	200×75×10,5 *232*	200×75×12 *252*	*274*
7,5	645	6,00		150×75×10 *125*	*6,0*	180×75× 8 *160*	180×75× 9 *170*	180×75×10,5 *187*	*199*	200×75× 9 *215*	200×75×10 *230*	200×75×11,5 *248*	200×90×13 *268*	*290*
7,8	655	6,25		165×75× 9 *135*	*5,8*	180×75× 9,5 *172*	180×75×10,5 *182*	*201*	200×75× 9 *214*	200×75×10 *230*	200×75×11,5 *246*	200×90×12,5 *264*	*285*	*310*
8,1	665	6,50		165×75×10 *146*	*5,6*	180×75×10,5 *187*	*197*	200×75× 9 *216*	200×75×10 *229*	200×75×11 *245*	200×90×12,5 *263*	*282*	*304*	230×90×1 *330*
8,4	680	6,75		180×75× 8 *157*	*5,4*	*202*	200×75× 9 *212*	200×75×10 *231*	200×75×11 *245*	200×75×12 *260*	*280*	*300*	230×90×11 *324*	230×90×1 *351*
8,7	695	6,95		180×75× 9 *169*	*5,2*	200×75× 9 *218*	200×75×10 *228*	200×75×11,5 *247*	200×90×12,5 *262*	*277*	*298*	230×90×11 *320*	230×90×12,5 *346*	*374*
9,0	705	7,15		180×75×10,5 *183*	*5,0*	200×75×10,5 *236*	200×75×11,5 *246*	200×90×13 *265*	*280*	*297*	230×90×11 *318*	230×90×12 *341*	*368*	250×90×1 *399*

For notes see page 113

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*Correction to Modulus of Main Framing per 0,3 metre difference between d and d_b*		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — METRES							
					5,7	6,0	6,3	6,6	6,9	7,2	7,5	7,8
Metres	Mm.	Metres	Per cent		Millimetres — *Modulus—centimetres*[a]							
3,0	535	2,35	*14,9*	ANGLES								
3,3	540	2,60	*13,9*	ANGLES								
3,6	545	2,85	*12,9*	ANGLES								
3,9	550	3,10	*12,0*	ANGLES								
4,2	555	3,35	*11,1*	ANGLES								
4,5	565	3,60	*10,5*	BULB ANGLES								
4,8	570	3,85	*10,0*	BULB ANGLES	165×75× 9 *139*							
5,1	575	4,10	*9,5*	BULB ANGLES	180×75× 8 *156*	180×75× 9 *170*						
5,4	580	4,35	*9,0*	BULB ANGLES	180×75× 9,5 *175*	180×75×11 *192*	200×75× 9 *210*					
5,7	590	4,55	*8,5*	BULB ANGLES	*198*	200×75× 9,5 *216*	200×75×10,5 *235*	200×75×12 *255*				
6,0	595	4,75	*8,0*	BULB ANGLES	200×75× 9,5 *222*	200×75×11 *242*	200×90×13 *264*	*285*	*307*			
6,3	600	5,00	*7,5*	BULB ANGLES	200×75×11 *242*	200×90×13 *264*	*286*	*309*	230×90×11 *334*	230×90×13 *358*		
6,6	605	5,25	*7,0*	BULB ANGLES	200×90×12,5 *260*	*282*	*306*	230×90×11,5 *330*	230×90×13 *357*	*382*	250×90×11,5 *410*	
6,9	615	5,50	*6,6*	BULB ANGLES	*277*	*301*	230×90×11 *327*	230×90×12,5 *354*	*383*	250×90×11,5 *411*	250×90×13 *440*	*470*
7,2	630	5,75	*6,3*	BULB ANGLES	*296*	230×90×11 *321*	230×90×12,5 *350*	*378*	250×90×11,5 *409*	250×90×12,5 *438*	*470*	*504*
7,5	645	6,00	*6,0*	BULB ANGLES	*315*	230×90×12 *342*	*371*	*402*	250×90×12,5 *434*	250×90×14 *465*	*500*	*535*
7,8	655	6,25	*5,8*	BULB ANGLES	230×90×11,5 *334*	230×90×13 *364*	*395*	250×90×12 *428*	250×90×14 *462*	*495*	*531*	280×90×13,5 *569*
8,1	665	6,50	*5,6*	BULB ANGLES	230×90×13 *357*	*387*	250×90×12 *422*	250×90×13,5 *455*	*492*	*525*	280×90×13 *563*	280×90×14,5 *604*
8,4	680	6,75	*5,4*	BULB ANGLES	*380*	250×90×11,5 *414*	250×90×13 *448*	*484*	*522*	280×90×12,5 *556*	280×90×14,5 *597*	*640*
8,7	695	6,95	*5,2*	BULB ANGLES	250×90×11 *405*	250×90×13 *440*	*475*	*512*	280×90×12,5 *552*	280×90×14 *591*	*633*	300×90×13,5 *677*
9,0	705	7,15	*5,0*	BULB ANGLES	250×90×12,5 *430*	250×90×14 *465*	*504*	280×90×12 *542*	280×90×14 *585*	*625*	300×90×13 *670*	300×90×15 *717*

For notes see page 113

TABLE 12
(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*Correction to Modulus of Main Framing per 0,3 metre difference between d and d_b*		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK METRES							
					8,1	8,4	8,7	9,0	9,3	9,6	9,9	10,2
Metres	Mm.	Metres	Per cent		Millimetres *Modulus—centimetres³*							
3,0	535	2,35	*14,9*	ANGLES								
3,3	540	2,60	*13,9*									
3,6	545	2,85	*12,9*									
3,9	550	3,10	*12,0*									
4,2	555	3,35	*11,1*									
4,5	565	3,60	*10,5*	BULB ANGLES								
4,8	570	3,85	*10,0*									
5,1	575	4,10	*9,5*									
5,4	580	4,35	*9,0*									
5,7	590	4,55	*8,5*									
6,0	595	4,75	*8,0*									
6,3	600	5,00	*7,5*									
6,6	605	5,25	*7,0*									
6,9	615	5,50	*6,6*									
7,2	630	5,75	*6,3*		280×90×12 *539*							
7,5	645	6,00	*6,0*		280×90×13,5 *572*	280×90×14,5 *610*						
7,8	655	6,25	*5,8*		280×90×14,5 *608*	*647*	300×90×13,5 *685*	300×90×15 *726*				
8,1	665	6,50	*5,6*		*645*	300×90×13,5 *685*	300×90×15 *727*	300×100×100×13 *769*	300×100×100×14,5 *813*			
8,4	680	6,75	*5,4*		300×90×13,5 *684*	300×90×15 *727*	300×100×100×13 *772*	300×100×100×14,5 *817*	300×100×100×16,5 *863*	320×100×100×14,5 *909*		
8,7	695	6,95	*5,2*		300×90×15 *724*	300×100×100×13 *771*	300×100×100×14,5 *817*	300×100×100×16,5 *864*	320×100×100×14,5 *911*	*959*	350×100×100×15 *1006*	
9,0	705	7,15	*5,0*	CH.	*765*	300×100×100×14,5 *814*	300×100×100×16,5 *863*	380×100×100×14,5 *913*	*964*	*1014*	381×100×100×13 *1065*	381×100×100× *1114*

For notes see page 113

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	FRAMING IN PEAKS	Correction to Modulus of Main Framing per 0,3 metre difference between d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK								
					METRES								
					2,4	3,0	3,6	3,9	4,2	4,5	4,8	5,1	5,4
Metres	Mm.	Metres	Millimetres *Modulus—cms.*³	Per cent	< Millimetres *Modulus—centimetres*³ >								
9,3	715	7,40	*197*	*4,8*	200×90×11,5 *252*	200×90×12,5 *263*	*283*	*298*	230×90×11 *315*	230×90×12 *337*	230×90×13 *362*	*390*	250×90×12 *422*
9,6	730	7,65	200×75×9 *214*	*4,6*	200×90×13 *273*	*282*	*302*	230×90×11 *317*	230×90×11,5 *335*	230×90×13 *357*	*383*	250×90×11,5 *414*	250×90×13 *447*
9,9	745	7,90	200×75×10,5 *232*	*4,4*	*290*	*300*	230×90×11 *321*	230×90×12 *337*	230×90×13 *355*	*378*	250×90×11 *404*	250×90×12,5 *436*	250×90×14 *470*
10,2	755	8,15	200×75×11,5 *250*	*4,3*	*309*	*319*	230×90×12 *341*	230×90×13 *357*	*376*	250×90×11 *401*	250×90×12,5 *427*	250×90×14 *459*	*496*
10,5	765	8,40	*276*	*4,2*	230×90×11 *328*	230×90×12 *339*	230×90×13 *361*	*378*	250×90×11 *398*	250×90×12 *423*	250×90×13,5 *451*	*484*	*522*
10,8	780	8,65	*301*	*4,1*	230×90×12,5 *348*	230×90×13 *360*	*382*	250×90×11 *400*	250×90×12 *420*	250×90×13 *445*	*474*	*509*	280×90×12 *548*
11,1	795	8,85	230×90×11 *327*	*4,0*	*367*	*379*	250×90×11 *403*	250×90×12 *420*	250×90×13 *442*	250×90×14 *467*	*496*	280×90×12 *530*	280×90×13,5 *570*
11,4	805	9,00	230×90×12 *345*	*3,9*	*385*	*398*	250×90×12 *421*	250×90×13 *439*	250×90×14 *460*	*486*	*516*	280×90×12,5 *552*	280×90×14 *594*
11,7	815	9,15	*349*	*3,9*	*398*	250×90×11,5 *411*	250×90×12,5 *435*	250×90×13,5 *454*	*475*	*504*	280×90×12 *534*	280×90×13,5 *569*	*612*
12,0	830	9,15	230×90×12,5 *352*	*3,9*	250×90×11,5 *411*	250×90×12 *425*	250×90×13,5 *450*	*469*	*490*	*519*	280×90×12,5 *549*	280×90×14 *587*	*630*
12,3	845	9,15	*355*	*3,9*	250×90×12 *423*	250×90×13 *438*	250×90×14 *464*	*483*	*505*	*533*	280×90×13 *565*	280×90×14,5 *604*	*648*
12,6	855	9,15	230×90×13 *358*	*3,9*	250×90×12,5 *435*	250×90×13,5 *450*	*478*	*498*	*520*	280×90×12,5 *548*	280×90×13,5 *580*	*620*	300×90×13 *665*
12,9	865	9,15	*362*	*3,9*	250×90×13 *448*	250×90×14 *464*	*492*	*512*	280×90×12 *535*	280×90×13 *564*	280×90×14,5 *596*	*636*	300×90×13,5 *682*
13,2	880	9,15	*365*	*3,9*	250×90×13,5 *459*	*476*	*506*	*527*	280×90×12,5 *550*	280×90×13,5 *580*	*613*	*654*	300×90×14 *701*
13,5	895	9,15	*368*	*3,9*	*471*	*490*	*521*	280×90×12 *542*	280×90×13 *565*	280×90×14 *595*	*629*	300×90×13 *670*	300×90×15 *718*
13,8	905	9,15	*371*	*3,9*	*483*	*502*	280×90×12 *534*	280×90×12,5 *556*	280×90×13,5 *580*	*610*	*645*	300×90×13,5 *685*	300×90×15,5 *734*
14,1	915	9,15	*374*	*3,9*	*494*	*513*	280×90×12,5 *547*	280×90×13 *569*	280×90×14 *595*	*624*	300×90×13 *658*	300×90×14 *700*	300×90×16 *749*
14,4	930	9,15	*377*	*3,9*	*508*	*528*	280×90×13 *563*	280×90×14 *586*	*611*	*641*	300×90×13,5 *676*	300×90×15 *720*	*769*
14,7	945	9,15	*381*	*3,9*	*521*	280×90×12 *541*	280×90×13,5 *577*	280×90×14,5 *602*	*627*	*657*	300×90×14 *693*	300×90×15,5 *739*	300×100×100×13,5 *788*
15,0	955	9,15	*384*	*3,9*	*533*	280×90×12,5 *554*	280×90×14 *590*	*615*	*641*	300×90×13,5 *671*	300×90×14,5 *707*	300×90×16 *753*	300×100×100×14 *805*

BULB ANGLES

For notes see page 113

TABLE 12

(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	Correction to Modulus of Main Framing per 0,3 metre difference between d and d_b		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — METRES							
					5,7	6,0	6,3	6,6	6,9	7,2	7,5	7,8
Metres	Mm.	Metres	Per cent		Millimetres — *Modulus—centimetres³*							
9,3	715	7,40	*4,8*	BULB ANGLES	250×90×13,5 *455*	*493*	280×90×12 *533*	280×90×13,5 *572*	*617*	*659*	300×90×14,5 *706*	*755*
9,6	730	7,65	*4,6*	BULB ANGLES	*482*	*522*	280×90×13 *564*	280×90×14,5 *606*	*653*	300×90×14 *698*	*747*	300×100×100× *800*
9,9	745	7,90	*4,4*	BULB ANGLES	*508*	280×90×12,5 *549*	280×90×14 *594*	*638*	300×90×13,5 *685*	300×90×15,5 *733*	300×100×100×13,5 *785*	300×100×100× *840*
10,2	755	8,15	*4,3*	BULB ANGLES	280×90×12 *535*	280×90×13,5 *579*	*625*	300×90×13,5 *672*	300×90×15 *725*	300×100×100×13 *775*	300×100×100×15 *830*	320×100×100× *885*
10,5	765	8,40	*4,2*	BULB ANGLES	280×90×13 *562*	280×90×14,5 *609*	*657*	300×90×14,5 *706*	*761*	300×100×100×14,5 *815*	300×100×100×17 *872*	320×100×100× *934*
10,8	780	8,65	*4,1*	BULB ANGLES	280×90×14 *590*	*640*	300×90×14 *691*	*744*	300×100×100×14 *800*	300×100×100×16 *855*	320×100×100×15 *917*	*980*
11,1	795	8,85	*4,0*	BULB ANGLES	*615*	300×90×13 *669*	300×90×15 *724*	300×100×100×13 *779*	300×100×100×15,5 *838*	320×100×100×14 *895*	*958*	*1025*
11,4	805	9,00	*3,9*	BULB ANGLES	*640*	300×90×14 *695*	300×90×16 *750*	300×100×100×14,5 *808*	300×100×100×16,5 *868*	320×100×100×15,5 *928*	*994*	*1062*
11,7	815	9,15	*3,9*	BULB ANGLES	300×90×13 *660*	300×90×14,5 *714*	300×100×100×13 *771*	300×100×100×15 *828*	320×100×100×13,5 *889*	320×100×100×16 *949*	*1015*	381×100×100× *1082*
12,0	830	9,15	*3,9*	BULB ANGLES	300×90×13,5 *679*	300×90×15,5 *733*	300×100×100×13,5 *791*	300×100×100×16 *850*	320×100×100×14,5 *911*	*970*	*1036*	381×100×100× *1104*
12,3	845	9,15	*3,9*	BULB ANGLES	300×90×14 *695*	300×90×16 *752*	300×100×100×14,5 *810*	300×100×100×17 *870*	320×100×100×15,5 *931*	*990*	*1056*	381×100×100× *1125*
12,6	855	9,15	*3,9*	BULB ANGLES	300×90×14,5 *714*	300×100×100×13 *770*	300×100×100×15 *830*	320×100×100×14 *890*	320×100×100×16 *951*	*1010*	381×100×100×13 *1077*	381×100×100× *1147*
12,9	865	9,15	*3,9*	BULB ANGLES	300×90×15,5 *732*	300×100×100×13,5 *790*	300×100×100×16 *850*	320×100×100×14,5 *910*	*972*	*1031*	381×100×100×13,5 *1098*	381×100×100× *1166*
13,2	880	9,15	*3,9*	BULB ANGLES	300×90×16 *751*	300×100×100×14,5 *810*	300×100×100×17 *870*	320×100×100×15,5 *930*	*992*	*1052*	381×100×100×14 *1119*	381×100×100× *1186*
13,5	895	9,15	*3,9*	CHANNELS	300×100×100×13 *770*	300×100×100×15 *830*	320×100×100×14 *890*	320×100×100×16 *950*	*1012*	381×100×100×13 *1073*	381×100×100×14,5 *1139*	381×100×100× *1208*
13,8	905	9,15	*3,9*	CHANNELS	300×100×100×13,5 *787*	300×100×100×16 *847*	320×100×100×14,5 *908*	*969*	*1032*	381×100×100×13,5 *1094*	381×100×100×15 *1160*	381×100×100× *1230*
14,1	915	9,15	*3,9*	CHANNELS	300×100×100×14 *802*	300×100×100×16,5 *863*	320×100×100×15 *925*	*987*	*1052*	381×100×100×14 *1114*	381×100×100×15,5 *1180*	381×100×100× *1250*
14,4	930	9,15	*3,9*	CHANNELS	300×100×100×15 *824*	320×100×100×13,5 *885*	320×100×100×16 *947*	*1010*	381×100×100×13 *1074*	381×100×100×14,5 *1138*	381×100×100×16,5 *1204*	*1272*
14,7	945	9,15	*3,9*	CHANNELS	300×100×100×15,5 *842*	320×100×100×14,5 *904*	*966*	*1029*	381×100×100×13,5 *1094*	381×100×100×15 *1157*	381×100×100×17 *1224*	*1292*
15,0	955	9,15	*3,9*	CHANNELS	300×100×100×16,5 *860*	320×100×100×15 *923*	*986*	*1049*	381×100×100×14 *1114*	381×100×100×15,5 *1176*	381×100×100×17,5 *1244*	400×110×110× *1312*

For notes see page 113

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*Correction to Modulus of Main Framing per 0,3 metre difference between d and d_b*	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK							
				METRES							
				8,1	8,4	8,7	9,0	9,3	9,6	9,9	10,2
Metres	Mm.	Metres	Per cent	Millimetres *Modulus—centimetres*³							
9,3	715	7,40	*4,8*	300×100×100×14 *806*	300×100×100×16,5 *858*	320×100×100×14,5 *909*	*962*	*1016*	381×100×100×13 *1069*	381×100×100×14 *1122*	381×100×100×15,5 *1171*
9,6	730	7,65	*4,6*	300×100×100×16 *852*	320×100×100×14,5 *905*	*958*	*1013*	381×100×100×13 *1070*	381×100×100×14,5 *1127*	381×100×100×16 *1184*	381×100×100×17 *1237*
9,9	745	7,90	*4,4*	320×100×100×14 *895*	*952*	*1008*	381×100×100×13 *1066*	381×100×100×14 *1125*	381×100×100×16 *1185*	*1243*	400×110×110×14 *1300*
10,2	755	8,15	*4,3*	320×100×100×16 *943*	*1002*	*1060*	381×100×100×14 *1123*	381×100×100×16 *1184*	381×100×100×17,5 *1247*	400×110×110×14 *1308*	400×110×110×15 *1366*
10,5	765	8,40	*4,2*	*994*	*1055*	381×100×100×14 *1116*	381×100×100×15,5 *1180*	381×100×100×17,5 *1245*	400×110×110×14 *1311*	400×110×110×15,5 *1375*	400×110×110×17 *1437*
10,8	780	8,65	*4,1*	*1044*	381×100×100×14 *1109*	381×100×100×15,5 *1175*	381×100×100×17,5 *1242*	400×110×110×14 *1310*	400×110×110×15,5 *1380*	400×110×110×17 *1446*	*1511*
11,1	795	8,85	*4,0*	381×100×100×13 *1093*	381×100×100×15 *1160*	381×100×100×17 *1228*	*1298*	400×110×110×15,5 *1370*	400×110×110×17 *1442*	*1512*	*1581*
11,4	805	9,00	*3,9*	381×100×100×14,5 *1131*	381×100×100×16,5 *1201*	*1271*	400×110×110×14,5 *1344*	400×110×110×16,5 *1418*	*1492*		
11,7	815	9,15	*3,9*	381×100×100×15 *1151*	381×100×100×17 *1221*	*1291*	400×110×110×15 *1364*	400×110×110×17 *1439*	*1515*		
12,0	830	9,15	*3,9*	381×100×100×15,5 *1172*	381×100×100×17,5 *1241*	400×110×110×14 *1311*	400×110×110×15,5 *1384*	400×110×110×17,5 *1460*	*1540*		
12,3	845	9,15	*3,9*	381×100×100×16 *1192*	381×100×100×18 *1262*	400×110×110×14,5 *1332*	400×110×110×16,5 *1405*	400×110×110×18 *1482*	*1568*		
12,6	855	9,15	*3,9*	381×100×100×16,5 *1214*	*1284*	400×110×110×15 *1354*	400×110×110×17 *1427*	*1505*	*1587*		
12,9	865	9,15	*3,9*	381×100×100×17 *1235*	400×110×110×14 *1304*	400×110×110×15,5 *1375*	400×110×110×17,5 *1449*	*1526*	*1610*		
13,2	880	9,15	*3,9*	381×100×100×17,5 *1255*	400×110×110×14,5 *1326*	400×110×110×16 *1397*	400×110×110×18 *1470*	*1550*	*1633*		
13,5	895	9,15	*3,9*	*1275*	400×110×110×14,5 *1346*	400×110×110×16,5 *1418*	*1492*	*1570*			
13,8	905	9,15	*3,9*	*1296*	400×110×110×15 *1367*	400×110×110×17 *1439*	*1514*	*1590*			
14,1	915	9,15	*3,9*	400×110×110×14 *1317*	400×110×110×15,5 *1387*	400×110×110×17,5 *1459*	*1533*	*1610*			
14,4	930	9,15	*3,9*	400×110×110×14,5 *1340*	400×110×110×16,5 *1410*	400×110×110×18 *1481*	*1557*				
14,7	945	9,15	*3,9*	400×110×110×15 *1361*	400×110×110×17 *1431*	*1502*					
15,0	955	9,15	*3,9*	400×110×110×15,5 *1381*	400×110×110×17,5 *1451*	*1523*					

CHANNELS

NOTES.—TABLE 12

1. **Correction to modulus of peak framing.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by 9 per cent per 0,3 metre of difference.

2. **Corrections to modulus of main framing.**—The Table modulus is to be corrected, if necessary, as follows:—

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per 0,3 metre of difference.

FOR TANK SIDE BRACKETS AND BEAM KNEES.

If the height of the tank side brackets above the inner bottom is greater than that derived from Tables 6 and 11 or the depth of the beam knees greater than that required by Table 28 the modulus may be reduced at the rate of 4 per cent per 0,3 metre of difference.

If the height of the tank side brackets above the inner bottom is less than that derived from Tables 6 and 11 the modulus is to be increased at the rate of 8 per cent per 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also D 604 to D 607.)

3. For framing in deep water ballast tanks, in oil fuel bunkers and in machinery spaces *see* D 19, D 20 and D 22.

4. For increase in boiler rooms and coal bunkers *see* D 614.

5. Particulars of sections and moduli are given in Table 56.

TABLE 13

'TWEEN DECK FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS PER 0.3 METRE DIFFERENCE BETWEEN d and d_b		A	B	C	D	E	F	
Metres	Mm.	Metres	Per cent		MILLIMETRES *Modulus—Cms.³*						
3,6	545	2,85	*13,8*	ANGLES		75×65× 7 *15,0*	75×65×10 *21,0*			75×65× 7 *15,0*	ANGLES
4,2	555	3,35	*13,4*			75×75× 8,5 *18,0*	90×75× 9 *26,0*			75×75× 7,5 *16,5*	
4,8	570	3,85	*12,9*			90×75× 7,5 *22,0*	100×75× 9 *32,0*			75×75× 8,5 *18,5*	
5,4	580	4,35	*12,4*			90×75× 9 *26,5*	100×75×11 *39,0*	130×75× 9 *52,5*		75×75×10 *21,0*	
6,0	595	4,75	*11,9*			90×75×11 *31,5*	130×75× 8,5 *47,5*	130×75×11 *63,5*		90×75× 8 *24,0*	
6,6	605	5,25	*11,3*			100×75×10,5 *37,0*	130×75×10 *58,0*	150×75×10 *75,0*		100×75× 8 *28,0*	
7,2	630	5,75	*10,7*		100×75×10 *35,5*	130×75× 8 *44,0*	150×75× 9,5 *71,5*	*88,0*		100×75× 9 *32,5*	
7,8	655	6,25	*10,1*		100×75×12,5 *43,0*	130×75× 9 *51,5*	150×75×12 *87,0*	150×75× 8 *103*	*140*	100×75×11 *38,0*	
8,4	680	6,75	*9,6*		130×75× 9 *52,0*	130×75×10,5 *60,0*	150×75× 8 *104*	150×75×10 *121*	180×90× 8,5 *164*	130×75× 8 *45,0*	
9,0	705	7,15	*9,0*		130×75×11 *62,0*	150×75× 9,5 *71,0*	150×75×10,5 *125*	165×75× 9,5 *142*	180×90×11 *191*	130×75× 9 *53,0*	
9,6	730	7,65	*8,3*		150×75×10 *73,5*	150×75×11,5 *83,5*	165×75×10 *148*	180×90× 9 *169*	*219*	130×75×11 *62,5*	
10,2	755	8,15	*7,5*		150×75×12 *86,5*	150×75× 7,5 *99,5*	180×90× 9,5 *173*	*203*	200×90×12 *252*	150×75×10 *73,5*	
10,8	780	8,65	*6,7*	BULB ANGLES	150×75× 7,5 *102*	150×75×10 *119*	*203*	200×90×11 *242*	*289*	150×75×11,5 *85,0*	BULB ANGLES
11,4	805	9,00	*6,1*		150×75×10 *122*	165×75× 9,5 *142*	200×90×11 *242*	*283*	*329*	150×75×13 *97,0*	
12,0	830	9,15	*5,9*		165×75× 8 *129*	165×75×10,5 *151*	200×90×12 *257*	*300*	230×90×12,5 *353*	150×75× 8 *106*	
12,6	855	9,15	*5,9*		165×75× 9 *136*	180×90× 8,5 *159*	200×90×13 *271*	*317*	*378*	150×75× 9 *114*	
13,2	880	9,15	*5,9*		165×75× 9,5 *143*	180×90× 9 *168*	*286*	230×90×11,5 *334*	250×90×11 *403*	150×75×10 *122*	
13,8	905	9,15	*5,9*		165×75×10,5 *151*	180×90× 9,5 *176*	*301*	230×90×12,5 *350*	250×90×12,5 *428*	165×75× 8 *130*	
14,4	930	9,15	*5,9*		180×90× 8 *158*	180×90×10,5 *185*	*315*	*367*	250×90×13,5 *453*	165×75× 9 *138*	
15,0	955	9,15	*5,9*		180×90× 9 *165*	180×90×11,5 *194*	230×90×11,5 *330*	*384*	*478*	165×75×10 *147*	

For notes see page 115

NOTES.—TABLE 13

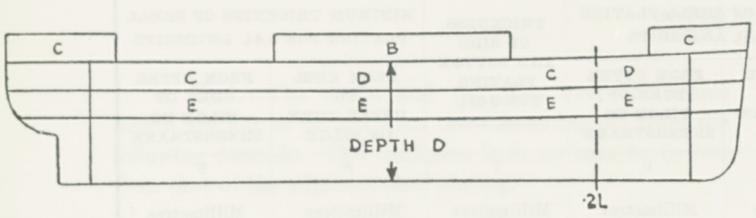


Diagram I

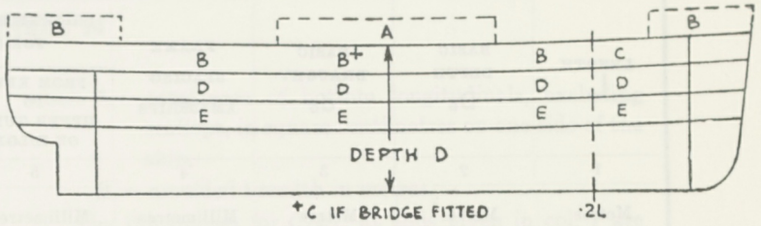


Diagram II

1. **Scantlings.**—The scantlings of the 'tween deck frames are given in cols. A to F. The positions to which each column between A and E applies are shown in the diagrams; for col. F *see* note 3. The scantlings given in the Table apply to frames fitted at every frame.

Diagram I is to be used when the ratio of draught d to depth D exceeds 0,75.

Diagram II is to be used when the ratio of draught d to depth D is—

less than 0,68 when D exceeds 6,7 metres
„ „ 0,60 „ D is 5,5 metres;
intermediate values to be obtained by interpolation.

When the value of the ratio d/D falls between the limits defined above the scantlings of the framing are to be determined by interpolation.

2. **Corrections to modulus of framing.**

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b modulus to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentage given in the Table per 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also D 604 to D 607.)

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height at side is greater than 2,6 metres, modulus to be increased in direct proportion.

3. If the framing in a 'tween deck consists of alternate frames extended from below with intermediate frames the mean modulus per frame space is to be as required for uniform framing, but the modulus of the intermediate frames is not to be less than that given in col. F. If frames are fitted two spaces apart (*see* D 609) the mean modulus per frame space is to be maintained.

4. Where several tiers of superstructures are fitted the scantlings and arrangements of the framing will be specially considered.

5. For increase in 'tween deck bunkers *see* D 614.

6. Particulars of sections and moduli are given in Table 56.

TABLE 14

SHELL PLATING

LENGTH L	BASIC DEPTH D_b	BASIC DRAUGHT d_b	FRAME SPACING AMIDSHIPS	THICKNESS OF SHELL PLATING FOR 0,4 L AMIDSHIPS		THICKNESS OF SIDE AND BOTTOM PLATING FOR 0,05 L FROM ENDS	MINIMUM THICKNESS OF SHELL PLATING FOR 0,4 L AMIDSHIPS	
				FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE		FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE
1	2	3	4	5	6	7	8	9
Metres	Metres	Metres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
30	3,00	2,00	540	6,5	6,5	6,5	6,5	6,5
35	3,25	2,40	550	7	7	6,5	7	7
40	3,50	2,70	560	7,5	7,5	7	7,5	7
45	3,75	3,00	570	8,5	8	7,5	8	7,5
50	4,00	3,40	580	9	8,5	8	8,5	8
55	4,30	3,70	590	9,5	8,5	8	8,5	8
60	4,80	4,00	600	10	9	8	9	8,5
65	5,30	4,30	610	10	9,5	8,5	9,5	9
70	5,80	4,60	620	10,5	10	8,5	9,5	9,5
75	6,30	4,90	630	11	10,5	9	10	10
80	6,80	5,20	640	11,5	10,5	9	10,5	10
85	7,30	5,50	650	12	11	9,5	11	10,5
90	7,80	5,80	660	12	11,5	9,5	11	10,5
95	8,30	6,10	670	12,5	12	9,5	11,5	11
100	8,80	6,50	680	13	12,5	10	11,5	11
105	9,30	6,90	690	13,5	13	10	12	11,5
110	9,80	7,30	700	14,5	13,5	10	12,5	11,5
115	10,30	7,80	710	15	14	10	13	12
120	10,80	8,30	720	15,5	14,5	10,5	13,5	12,5
125	11,30	8,70	730	16	15	10,5	13,5	12,5
130	11,80	8,90	740	16,5	15	11	14	13
135	12,30	9,10	750	17	15,5	11	14,5	13,5
140	12,80	9,30	760	17,5	15,5	11,5	15	14
145	13,30	9,50	770	18	16	11,5	15,5	14,5
150	13,80	9,70	780	18,5	16,5	11,5	16,5	15
155	14,30	9,90	790	19	16,5	12	17	15,5
160	14,80	10,00	800	19,5	17	12	17,5	16
165	15,30	10,15	810	20	17,5	12	18	16,5
170	15,80	10,30	820	20,5	18	12,5	18,5	16,5
175	16,30	10,45	830	21	18,5	12,5	19	16,5
180	16,80	10,55	840	21,5	18,5	12,5	19,5	17
185	17,30	10,65	850	22	19	13	20	17
190	17,80	10,75	860	22,5	19,5	13	20,5	17
195	18,30	10,85	870	23	20	13	21	17
200	18,80	10,95	880	23.5	20 5	13	21	17

For notes see page 117

NOTES.—TABLE 14

1. Keel.—The width and thickness over the whole length are not to be less than the values derived from the following formulæ. The thickness is in no case to be less than that of the adjacent shell plating.

$$\text{Width} = 762 + \frac{25L}{6} \text{ mm.}$$

$$\text{Thickness} = 5{,}84 + \frac{5L}{48} \text{ mm.}$$

2. Garboard strake.—If a bar keel is fitted, the thickness of the garboard strake is to be 85 per cent of that required for a keel plate (Note 1); this thickness is to be maintained for 0,4L amidships and may be 85 per cent of the midship thickness for 0,05L at the ends, but in way of strengthening of bottom forward is not to be less than required for bottom plating.

3. Bottom and side plating.—The Table thickness of bottom and side plating for 0,4L amidships (cols. 5 and 6) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than D_b, thickness to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by 0,7 per cent per 0,3 metre of difference.

FOR DRAUGHT.

If d is less than d_b, thickness to be reduced by 1,5 per cent per 0,3 metre of difference. If d is greater than d_b, no correction is required.

If both these corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth* +1,22%; *correction for draught* −3,37%; *total factor* 1,012×0,966 = 0,978).

For Longitudinal framing

Where the bottom is framed longitudinally the thickness of the bottom shell plating, after correction for depth and draught, if necessary, may be reduced by $\frac{0{,}18A}{B}$ mm.

where A = total area of bottom longitudinals, excluding scallops, in square centimetres on one side of the ship,

B = moulded breadth in metres.

The thicknesses for 0,05L at ends given in col. 7 are not subject to the above corrections.

4. Effective superstructure.—If an effective superstructure as defined in D 206 is fitted, the shell plating may be modified as stated in D 703.

5. Frame spacing.—If the spacing amidships differs from the Table spacing (col. 4) the thickness of bottom and side plating is to be modified at the rate of 0,5 mm. for every 50 mm. of difference, but where the spacing amidships exceeds the Table spacing by 75 mm. or more the increase required will be specially considered.

Where the bottom is framed longitudinally a spacing correction is only required (except as given in Note 6) if the spacing exceeds that given in Table 10 by 75 mm. or more when the increase required will be specially considered.

6. Minimum thickness.—The thickness of the bottom and side plating for 0,4L amidships, after correction as required by Notes 3 and 5, is not to be less than that given in cols. 8 and 9, corrected as required by Note 5 only.

Where the bottom is framed longitudinally the minimum thickness of bottom shell (col. 8) is to be modified at the rate of 0,5 mm. for every 50 mm. of difference between the actual spacing and that given in Table 10.

7. Local strengthening.—Plates connected to the sternframe or propeller brackets are to have the thickness given in col. 6 without corrections and those which require to be furnaced are to be of that thickness when finished.

For strengthening of bottom forward *see* D 802.

For strengthening at openings in shell *see* D 705 and D 706.

For strengthening at ends of superstructures *see* D 1206 and D 1305 to D 1308.

For strengthening for navigation in ice *see* D 1004 to D 1009, D 1018 to D 1020, D 1028 and D 1035.

TABLE 15

BEAMS IN PEAKS BELOW LOWEST DECK

BREADTH B		BEAM	KNEE	RIVETS	
Metres		Millimetres	Millimetres	Number	mm.
7	BULB ANGLES	130× 65× 8	380× 8	4	19
8		140× 65× 8	385× 8	4	19
9		140× 65× 9	415× 8,5	5	19
10		150× 75× 9	445× 8,5	6	19
11		150× 75×10,5	485× 9	6	19
12		165× 75×10,5	525× 9,5	6	19
13		180× 75×11	565× 9,5	6	22
14		180× 90×11,5	610× 9,5	6	22
15		200× 90×11,5	650×10	6	22
16		230× 90×11	690×10,5	7	22
17	CHANNELS	200× 85× 85×12	735×11	7	22

NOTE.—TABLE 15

Where B is greater than 17 metres the scantlings of the beams are to be specially considered in relation to the size and form of the ship.

TABLE 16

STRINGERS IN PANTING REGION

LENGTH L	FORWARD OF COLLISION BULKHEAD		ABAFT COLLISION BULKHEAD		
	STRINGER PLATE		THICKNESS OF INTERCOSTAL PLATE	FACE ANGLE	
	WIDTH	THICKNESS			
Metres	Millimetres	Millimetres	Millimetres		Millimetres
30	555	6,5	7	ANGLES	65 × 65 × 7,5
60	630	7,5	8	ANGLES	75 × 75 × 9,0
90	705	8	9	ANGLES	120 × 75 × 10,0
120	805	9	10	ANGLES	150 × 90 × 10,5
150	905	9,5	10,5	BULB ANGLES	180 × 90 × 10,5
180	1005	10,5	11,5	BULB ANGLES	200 × 90 × 12,0

TABLE 17

ICE STRENGTHENING—CLASS 3
INTERMEDIATE FRAMES

LENGTH L	INTERMEDIATE FRAMES			
	FORWARD OF COLLISION BULKHEAD		ABAFT COLLISION BULKHEAD	
Metres	Millimetres *Modulus—Centimetres³*			
30	ANGLES	75 × 65 × 7,0 *15,1*	ANGLES	100 × 75 × 9,0 *32,4*
40	ANGLES	75 × 75 × 8,5 *18,2*	ANGLES	100 × 75 × 11,0 *38,7*
60	ANGLES	90 × 75 × 9,5 *27,2*	ANGLES	120 × 75 × 11,5 *56,2*
80	ANGLES	120 × 75 × 9,0 *43,9*	ANGLES	150 × 75 × 11,0 *82,9*
100	ANGLES	150 × 75 × 9,0 *68,0*	BULB ANGLES	150 × 75 × 9,5 *118,0*
120	ANGLES	150 × 90 × 13,5 *97,7*	BULB ANGLES	180 × 75 × 8,5 *161,0*
140	ANGLES	180 × 90 × 12,5 *131,0*	BULB ANGLES	200 × 75 × 9,0 *211,0*
160	BULB ANGLES	180 × 75 × 8,5 *163,0*	BULB ANGLES	200 × 90 × 12,5 *262,0*

TABLE 18

(SEE CONTINUATION)

TOPSIDE SCANTLINGS

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	BEAM SPACING AMIDSHIPS	WIDTH OF SHEERSTRAKE AND STRINGER PLATE OF PLATED DECK.	THICKNESS OF SHEERSTRAKE FOR 0,4L AMIDSHIPS	SECTIONAL AREAS OF STRENGTH DECK FOR 0,4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM. (Col.17) WHERE ONE DECK FITTED		
							SECTIONAL AREA	*CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:* D *and* D_b	*CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:* d *and* d_b
1	2	3	4	5	6	7	8	9	10
Metres	Metres	Metres	Metres	Millimetres	Millimetres	Millimetres	Square Centimetres	Per cent	Per cent
30	7,5	3,00	2,00	540	1060	7,5	70	*18,15*	*18,20*
35	8	3,25	2,40	550	1070	8	85	*14,90*	*16,60*
40	8,5	3,50	2,70	560	1120	8,5	100	*12,95*	*15,40*
45	9	3,75	3,00	570	1150	9,5	130	*11,45*	*14,40*
50	9,5	4,00	3,40	580	1165	10	165	*10,35*	*13,10*
55	10	4,3	3,70	590	1195	10,5	200	*9,50*	*12,15*
60	10,5	4,8	4,00	600	1235	11,5	235	*8,80*	*11,10*
65	11	5,3	4,30	610	1270	12	270	*8,10*	*10,25*
70	11,5	5,8	4,60	620	1300	12,5	305	*7,55*	*9,45*
75	12	6,3	4,90	630	1320	13	345	*7,15*	*8,65*
80	12,5	6,8	5,20	640	1345	13,5	390	*6,75*	*7,90*
85	13	7,3	5,50	650	1365	14	450	*6,40*	*7,20*
90	13,5	7,8	5,80	660	1385	14,5	520	*6,15*	*6,70*
95	14	8,3	6,10	670	1405	15	595	*5,90*	*6,15*
100	14,5	8,8	6,50	680	1425	15,5	675	*5,65*	*5,55*
105	15	9,3	6,90	690	1445	16	760	*5,40*	*5,00*
110	15,5	9,8	7,30	700	1470	17	885	*5,15*	*4,55*
115	16	10,3	7,80	710	1490	18,5	1010	*4,90*	*4,15*
120	16,5	10,8	8,30	720	1510	19,5	1140	*4,70*	*3,75*
125	17	11,3	8,70	730	1530	20,5	1280	*4,45*	*3,60*
130	17,5	11,8	8,90	740	1550	21	1380	*4,25*	*3,60*
135	18	12,3	9,10	750	1570	21,5	1495	*4,10*	*3,55*
140	18,5	12,8	9,30	760	1595	21,5	1605	*3,95*	*3,55*
145	19	13,3	9,50	770	1615	22			
150	19,5	13,8	9,70	780	1635	22,5			
155	20	14,3	9,90	790	1655	23			
160	20,5	14,8	10,00	800	1675	23,5			
165	21	15,3	10,15	810	1700	24,5			
170	21,5	15,8	10,30	820	1720	25			
175	22	16,3	10,45	830	1740	26			
180	22,5	16,8	10,55	840	1755	27			
185	23	17,3	10,65	850	1795	28			
190	23,5	17,8	10,75	860	1835	28,5			
195	24	18,3	10,85	870	1880	29,5			
200	24,5	18,8	10,95	880	1920	30			

For notes see pages 122 & 123

SECTIONAL AREA OF STRENGTH DECK FOR 0,4 L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM							MINIMUM THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR 0,4 L AMIDSHIPS		THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR 0,1 L FROM ENDS		LENGTH L
WHERE TWO DECKS FITTED			WHERE THREE DECKS FITTED			ALL STRENGTH DECKS					
SECTIONAL AREA	CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:		SECTIONAL AREA	CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:		CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN	OUTSIDE LINE OF OPENINGS	INSIDE LINE OF OPENINGS	STRINGER	PLATING	
	D and D_b	d and d_b		D and D_b	d and d_b	B and B_b					
11	12	13	14	15	16	17	18	19	20	21	22
Square Centimetres	Per cent	Per cent	Square Centimetres	Per cent	Per cent	Per cent	Millimetres	Millimetres	Millimetres	Millimetres	Metres
						3,95	6,5	6,5	6,5	6,5	30
						3,95	6,5	6,5	6,5	6,5	35
						3,95	7	7	7	6,5	40
						3,95	7	7	7	6,5	45
						3,95	7,5	7	7,5	7	50
180	*13,40*	*9,85*				*3,95*	8	7	7,5	7	55
210	*12,45*	*9,55*				*3,95*	8	7,5	8	7	60
240	*11,65*	*9,35*				*3,95*	8	7,5	8	7	65
270	*10,85*	*9,10*				*3,95*	8,5	7,5	8	7	70
305	*10,10*	*8,85*				*3,95*	8,5	7,5	8,5	7,5	75
350	*9,35*	*8,50*				*3,95*	9	8	8,5	7,5	80
395	*8,85*	*8,20*				*3,95*	9	8	9	7,5	85
440	*8,45*	*7,85*				*3,95*	9,5	8	9	7,5	90
495	*8,05*	*7,25*				*3,80*	9,5	8,5	9	7,5	95
560	*7,70*	*6,50*	540	*9,80*	*6,85*	*3,65*	9,5	8,5	9,5	8	100
625	*7,45*	*5,95*	595	*9,15*	*6,25*	*3,50*	10	8,5	9,5	8	105
715	*7,15*	*5,35*	690	*8,50*	*5,55*	*3,35*	10	9	10	8	110
825	*6,80*	*4,80*	795	*8,00*	*5,00*	*3,20*	10,5	9	10	8	115
940	*6,55*	*4,30*	895	*7,60*	*4,50*	*3,00*	10,5	9	10	8	120
1030	*6,30*	*4,05*	1000	*7,25*	*4,25*	*2,85*	11	9	10	8,5	125
1115	*5,95*	*3,95*	1075	*7,00*	*4,15*	*2,70*	11	9	10	8,5	130
1205	*5,70*	*3,85*	1160	*6,80*	*4,05*	*2,55*	11,5	9,5	10,5	8,5	135
1295	*5,40*	*3,75*	1235	*6,60*	*3,95*	*2,35*	11,5	9,5	10,5	8,5	140
1385	*5,10*	*3,70*	1305	*6,45*	*3,90*	*2,20*	12	9,5	10,5	8,5	145
1485	*4,80*	*3,70*	1375	*6,30*	*3,85*	*2,05*	12	9,5	10,5	8,5	150
1580	*4,50*	*3,65*	1460	*5,95*	*3,85*	*2,00*	12	9,5	10,5	9	155
1730	*4,10*	*3,60*	1580	*5,25*	*3,75*	*2,00*	12,5	10	11	9	160
1870	*3,70*	*3,55*	1710	*4,80*	*3,70*	*2,00*	12,5	10	11	9	165
2005	*3,40*	*3,45*	1840	*4,35*	*3,60*	*2,00*	12,5	10	11	9	170
2140	*3,20*	*3,45*	1965	*3,90*	*3,55*	*2,00*	12,5	10	11	9	175
			2110	*3,55*	*3,50*	*2,00*	12,5	10	11	9	180
			2240	*3,35*	*3,45*	*2,00*	12,5	10,5	11,5	9	185
			2365	*3,15*	*3,45*	*2,00*	12,5	10,5	11,5	9,5	190
			2510	*3,05*	*3,40*	*2,00*	12,5	10,5	11,5	9,5	195
			2645	*2,90*	*3,40*	*2,00*	12,5	10,5	11,5	9,5	200

For notes see pages 122 & 123

NOTES.—TABLE 18

1. **Sheerstrake.**—(*a*) The Table thickness of the sheerstrake (col. 7) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than D_b, thickness to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by 4 per cent per 0,3 metre of difference.

FOR DRAUGHT.

If d is less than d_b, thickness to be reduced by 4 per cent per 0,3 metre of difference. If d is greater than d_b, no correction is required.

If both corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth* +7,32%; *correction for draught* −10,16%; *total factor* =1,073×0,898=0,964.)

(*b*) The thickness of sheerstrake is not to be corrected for frame spacing, but is not to be less, for 0,4L amidships, than the side plating.

The thickness of sheerstrake at ends is to be the same as that of the side plating except in ships in which the draught does not exceed 0,7D (D being measured to the uppermost continuous deck) when the end thickness may be as required for a poop or forecastle aft or forward respectively.

2. **Plated strength deck.**—(*a*) The area given in cols. 8, 11 and 14 is the combined sectional area of deck plating, stringer plate and, where fitted, stringer angle, deck longitudinals (with area of scallops deducted) and riveted seams for one side of the ship abreast openings.

(*b*) The Table area (cols. 8, 11 and 14) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than D_b, area to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by the given percentage (cols. 9, 12 and 15) per 0,3 metre of difference.

FOR DRAUGHT.

If d is less than d_b, area to be reduced by the given percentage (cols. 10, 13 and 16) per 0,3 metre of difference. If d is greater than d_b, no correction is required.

FOR BREADTH.

If B is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than B_b, area to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the given percentage (col. 17) per 0,3 metre of difference.

If more than one of the above corrections is required the factors derived from the individual corrections are to be multiplied together and not applied separately to the Table area. (*Example: Correction for depth* − 13,81%; *correction for draught* − 3,92%; *correction for breadth* + 9,12%; *total factor* = 0,862 × 0,961 × 1,091 = 0,904.)

The deck area obtained after the above corrections is the minimum area. This area may require to be increased for special characteristics in design as required in note 2(*c*).

(*c*) Where there is no effective superstructure (*see* D 206) on the strength deck, the sectional area of the strength deck plating as computed from notes 2(*a*) and 2(*b*) is to be increased by multiplying the area by the factor

$$F = \frac{L \times C_b}{100 \times d} \times f_1 \times f,$$ if this factor is greater than unity.

Where C_b = moulded block coefficient at load draught,

L = length between perpendiculars, in metres,

d = summer draught, in metres, measured from top of keel.

f_1 is a factor to be applied only when d is greater than d_b and

$$f_1 = 1 + \left(\frac{d - d_b}{30}\right) C_d$$

where C_d is the draught correction from cols. 10, 13 or 16 as appropriate.

f is to be determined in the following manner:—

Where l = length, in metres, of machinery space between main bulkheads including mean length of adjacent cross bunkers, if any.

x = distance, in metres, of centre of the length "l" from amidships.

m = weight of machinery, in metric tons, excluding propellers and shafting, but including all auxiliary machinery in machinery space.

W = load displacement, in metric tons.

V = sea speed, in knots.

s = product of length, mean breadth and height, in metres, of cargo space in forecastle, poop or after 'tween decks as defined below.

z = distance, in metres, of centre of length of above cargo space from amidships.

Then f is the algebraic summation of the following terms "a" and "b" in all cases and "c" and "d_t" where applicable.

"a", "b", "c" and "d_t" are obtained as follows:—

"a" is taken from Table 18A for the appropriate values of l/L and x/L.

"b" is calculated from Table 18B to give effect to any departure from a standard value of m/W = 0,06, and may be positive or negative.

"c". If a forecastle and/or poop is fitted on the continuous strength deck for the carriage of cargo, or if cargo is carried in the upper 'tween decks

NOTES.—TABLE 18 (*concluded*)

abaft 0,05L forward of the after perpendicular, a further term "c" is to be calculated and added as follows:—

For a forecastle, poop and/or after 'tween deck

$$\frac{136{,}3\ s(z - 0{,}25\ l - 0{,}2L)}{WL}$$

NOTE.—In calculating "s" for an after 'tween deck the length of the space need only be measured abaft 0,05L forward of the after perpendicular.

"d_t". If owners desire provision to be made in the longitudinal scantlings for loaded voyages with one or more midship deep tanks empty an additional term "d_t" calculated for each deep tank as follows is to be added to "a", "b" and "c" when calculating the value of "f".

$$d_t = \frac{150\ C\ (0{,}25\ l + 0{,}2L - y)}{WL}$$

Where C = capacity of deep tank, in metric tons, of salt water.

y = distance, in metres, of centre of length of deep tank from amidships.

This correction is applicable to ships having machinery amidships and for midship deep tanks only; it is not to be applied to tanks at ends where the value of "d_t" is negative.

Special consideration will be given to the scantlings when the speed-length ratio exceeds that obtained from the following table:—

C_b	$\frac{V}{\sqrt{L} \times 3{,}28}$
0,60	0,85
0,70	0,75
0,80	0,65

Special consideration will also be given when the block coefficient is less than 0,60.

(*d*) Where a long continuous deckhouse extending over at least 0,15L amidships and not less in breadth than 0,8B is fitted, the increased deck area required by note 2(*c*) may extend from a distance of 0,04L inside the deckhouse at each end to 0,2L from midships. Within the remainder of the deckhouse the deck area is to be that required by note 2(*b*). (For deckhouses *see* D 1208 to D 1211.)

(*e*) The requirements of notes 2(*c*) and 2(*d*) may be modified as necessary to take account of any special features in the design arrangements not covered by the formula.

3. **'Tween deck height.**—If the midship height of the 'tween decks below the strength deck exceeds 2,6 metres at side, the area of the strength deck, corrected as required by notes 2 (*b*), 2 (*c*) and 2 (*d*) is to be increased at the rate of 5 per cent of the Rule area of the second deck in two deck ships, and 7 per cent of the Rule area of the second deck in three deck ships, per 0,3 metre increase in 'tween deck height. If the second 'tween deck height exceeds 2,6 metres, a further increase may be required.

If the midship height of the 'tween decks below the strength deck is less than 2,6 metres at side, the area of the strength deck corrected as required by notes 2 (*b*), 2 (*c*) and 2 (*d*) may be reduced at the rate of 5 per cent of the Rule area of the second deck per 0,3 metre reduction in 'tween deck height.

4. **Beam spacing.**—If the spacing of beams amidships differs from that given in col. 5, or with longitudinal framing from that given in Table 26, the minimum thickness of deck plating outside line of openings (col. 18) is to be modified at the rate of 0,5 mm. for every 100 mm. of difference, and the minimum thickness of deck plating inside line of openings (col. 19) at the rate of 0,5 mm. for each complete 200 mm.

5. **Stringer plates.**—The thickness of strength deck stringer plates amidships is not to be less than 85 per cent of the thickness of sheerstrake, corrected as required by note 1, nor less than 1 mm. greater than that given in col. 18.

The width of stringer plates for 0,1L at ends is not to be less than 60 per cent of the width amidships (col. 6).

6. **Stringer angles.**—Scantlings are to be in accordance with Table 19.

7. **Sheathed decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in col. 18 may be reduced by 15 per cent in ships over 50 metres in length and by 10 per cent in smaller ships, and that given in cols. 19, 20 and 21 may be reduced by 10 per cent for all ships.

8. **Effective superstructures.**—If an effective superstructure as defined in D 206 is fitted amidships the scantlings of the upper and second decks in way of the superstructure are to be those required for the second and third decks respectively.

9. **Strength deck with stringer and tie plates.**—Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for 0,4L amidships, required for a plated deck.

The width of stringer plates for 0,4L amidships is not to be less than 560 mm. and 1370 mm. for lengths of 30 metres and 80 metres respectively with intermediate values in proportion. The width for 0,1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 300 mm. and 500 mm. for lengths of 30 metres and 80 metres respectively with intermediate values in proportion.

The thickness of the stringer and tie plates is not to be less than given in col. 20, but stringer plates for 0,4L amidships are not to be less than 85 per cent of the Rule thickness of sheerstrake.

10. **Local strengthening.**—For strengthening at the ends of superstructures *see* D 1206 and D 1305 to D 1308.

For strengthening at openings *see* D 1109.

For strengthening in ships having concentrated loading amidships *see* D 1107.

TABLE 18A

Term "a" of Basic Deck Factor f (Note 2 (c)) for $m/W = 0{,}06$

l/L	x/L					
	0,02	0,04	0,06	0,08	0,10	0,12
0,11	5,85	5,65	5,34	4,84	4,11	3,06
0,12	6,42	6,22	5,91	5,40	4,69	3,78
0,13	6,96	6,75	6,42	5,94	5,34	4,50
0,14	7,46	7,26	6,96	6,49	5,91	5,18
0,15	7,92	7,74	7,45	6,99	6,48	5,83
0,16	8,38	8,16	7,90	7,48	7,00	6,48
0,17	8,80	8,59	8,32	7,95	7,54	7,06
0,18	9,18	8,98	8,71	8,40	8,04	7,63
0,19	9,54	9,35	9,08	8,79	8,47	8,12
0,20	9,85	9,66	9,45	9,17	8,88	8,56
0,21	10,14	9,95	9,74	9,48	9,20	8,93

TABLE 18B

Term "b" of Basic Deck Factor f (Note 2(c))

Value per 0,01 Difference in m/W from 0,06

x/L	CORRECTION	x/L	CORRECTION
0,0	0,526	0,06	0,440
0,01	0,522	0,07	0,412
0,02	0,514	0,08	0,380
0,03	0,502	0,09	0,345
0,04	0,486	0,10	0,312
0,05	0,464	0,11	0,277
		0,12	0,242

The term "b" is $\frac{\text{positive}}{\text{negative}}$ when m/W is $\frac{\text{less}}{\text{greater}}$ than 0,06.

STRINGER ANGLES ON STRENGTH DECKS

THICKNESS OF SHEERSTRAKE OR STRINGER PLATE WHICHEVER IS THE GREATER		DIAMETER OF RIVET AS REQUIRED BY TABLE 52	SIZES OF FLANGES*	SPACING OF RIVETS
Above	Not exceeding	Millimetres	Millimetres	Diameters
Millimetres				
—	9	16	75 × 75	$4\frac{1}{2}$
9	12,5	19	90 × 90	$4\frac{1}{2}$
12,5	14	22	90 × 90	$4\frac{1}{2}$
14	16	22	90 × 90	$4\frac{1}{2}$
16	18,5	22	130 × 130	2 rows, 6 in each row
18,5	24	25	150 × 150	2 „ $5\frac{1}{2}$ „
24	29	28	180 × 180	2 „ $5\frac{1}{2}$ „
29	30,5	32	200 × 200	2 „ 5 „

* The thickness of the stringer angle is to be that of the sheerstrake or stringer plate, whichever is the less.

TABLE 20

LOWER DECKS

LENGTH L	BASIC BREADTH B_b	BEAM SPACING AMIDSHIPS	SECOND DECK PLATING OUTSIDE LINE OF OPENINGS FOR 0,4 L AMIDSHIPS		THIRD DECK PLATING OUTSIDE LINE OF OPENINGS FOR 0,4 L AMIDSHIPS		PLATING OF SECOND & THIRD DECKS INSIDE LINE OF OPENINGS & FOR 0,1 L FROM ENDS AND OF PLATFORM DECKS THROUGHOUT (UNSHEATHED)
			SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	
1	2	3	4	5	6	7	8
Metres	Metres	Millimetres	Square Cms.	Millimetres	Square Cms.	Millimetres	Millimetres
50	9,5	580	95	7			6,5
55	10	590	105	7			6,5
60	10,5	600	115	7,5			6,5
65	11	610	125	7,5			6,5
70	11,5	620	145	7,5			6,5
75	12	630	175	7,5			6,5
80	12,5	640	205	7,5			6,5
85	13	650	240	8			6,5
90	13,5	660	280	8			6,5
95	14	670	325	8			6,5
100	14,5	680	355	8	325	7,5	7
105	15	690	385	8	345	7,5	7
110	15,5	700	415	8,5	365	7,5	7
115	16	710	435	8,5	390	7,5	7
120	16,5	720	455	8,5	410	7,5	7
125	17	730	480	8,5	430	8	7,5
130	17,5	740	505	8,5	450	8	7,5
135	18	750	530	9	475	8	7,5
140	18,5	760	565	9	495	8	7,5
145	19	770	595	9	520	8	7,5
150	19,5	780	625	9	545	8,5	7,5
155	20	790	665	9,5	575	8,5	8
160	20,5	800	695	9,5	605	8,5	8
165	21	810	730	10	640	9	8
170	21,5	820	765	10	670	9	8
175	22	830	800	10,5	695	9	8
180	22,5	840	830	10,5	720	9,5	8
185	23	850	860	10,5	755	9,5	8
190	23,5	860	900	11	785	10	8,5
195	24	870	930	11	830	10	8,5
200	24,5	880	965	11	865	10	8,5

LOWER DECKS

NOTES.—TABLE 20

1. **Sectional area.**—The Table area of lower decks (cols. 4 and 6) is for one side of the ship outside the line of hatchways or other openings and inside the line of notches for 'tween deck frames; it includes overlapped seams, if fitted.

2. **Corrections.**

FOR BREADTH.

If B differs from B_b (col. 2) the area is to be modified in direct proportion.

FOR BEAM SPACING.

If the spacing of beams fitted at every frame, or of longitudinals, differs from that in col. 3 the minimum thickness of deck plating (cols. 5 and 7) is to be modified at the rate of 0,5 mm. for every 100 mm. of difference.

3. **Stringer plates and angles.**—The thickness of stringer plates may be the same as that of the deck plating. Angles connecting the deck to shell plating are to have the same thickness as the stringer or deck plating to which they are attached.

4. **Sheathed decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in cols. 5, 7 and 8 may be reduced by 10 per cent.

5. **Decks with stringer and tie plates.**—Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for 0,4L amidships, required for a plated deck.

The width of stringer plates from shell to inner edge, for 0,4L amidships, is not to be less than 965 mm. and 1170 mm. for lengths of 55 metres and 80 metres respectively with intermediate values in proportion. The width for 0,1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 300 mm. and 500 mm. for lengths of 55 metres and 80 metres respectively with intermediate values in proportion.

The thickness of the stringer and tie plates throughout is not to be less than given in col. 5.

TABLE 21 SHORT SUPERSTRUCTURES

LENGTH L	SIDE PLATING		WIDTH OF STRINGER AND TIE PLATES WITH WOOD DECK		THICKNESS OF STRINGER AND TIE PLATES WITH WOOD DECK			MINIMUM THICKNESS OF UNSHEATHED PLATED DECKS		
	POOP	BRIDGE & FORECASTLE	STRINGER	TIE PLATE	POOP	BRIDGE	FORECASTLE	POOP	BRIDGE	FORECASTLE
1	2	3	4	5	6	7	8	9	10	11
Metres	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
30	5,5	5,5	300	125	5,5	5,5	5,5	6	6	6
35	5,5	5,5	340	125	5,5	5,5	5,5	6	6	6
40	5,5	5,5	385	130	5,5	5,5	5,5	6	6	6
45	6	6	425	140	6	6	6	6	6	6
50	6	6,5	470	150	6	6,5	6,5	6,5	6,5	6,5
55	6,5	7	510	160	6,5	7	7	6,5	6,5	6,5
60	6,5	7	550	165	6,5	7	7	6,5	6,5	6,5
65	6,5	7	595	175	6,5	7	7	6,5	6,5	6,5
70	7	7,5	635	185	7	7,5	7,5	6,5	6,5	6,5
75	7	7,5	670	190	7	7,5	7,5	6,5	7	7
80	7,5	8	700	200	7,5	8	8	6,5	7	7
85	7,5	8,5	730	205	7,5	8,5		7	7	7
90	8	8,5	760	210	8	8,5		7	7	7
95	8	9	795	220	8	9		7	7	7
100	8	9	815	225	8	9		7	7,5	7,5
105	8,5	9,5	835	230	8,5	9,5		7	7,5	7,5
110	8,5	9,5	860	240	8,5	9,5		7	7,5	7,5
115	9	10	880	245	9	10		7	7,5	7,5
120	9	10	900	250	9	10		7	7,5	7,5
125	9	10	920	255	9			7	8	8
130	9,5	10,5	940	260	9,5			7,5	8	8
135	9,5	10,5	960	265	9,5			7,5	8	8
140	10	11	980	270	10			7,5	8	8
145	10	11	1005	275	10			7,5	8,5	8,5
150	10,5	11,5	1025	280	10,5			7,5	8,5	8,5
155	10,5	11,5	1045	285	10,5			7,5	8,5	8,5
160	10,5	11,5	1065	290	10,5			7,5	8,5	8,5
165	11	12	1085	295	11			8	8,5	8,5
170	11	12	1105	300	11			8	9	9
175	11,5	12,5	1130	300	11,5			8	9	9
180	11,5	12,5	1150	300	11,5			8	9	9
185	11,5	12,5	1170	300	11,5			8	9	9
190	12	13	1190	300	12			8	9	9
195	12	13	1210	300	12			8	9,5	9,5
200	12	13	1235	300	12			8	9,5	9,5

PLATED DECK REQUIRED

PLATED DECK REQUIRED

SHORT SUPERSTRUCTURES

NOTES.—TABLE 21

1. **Sheathed decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in cols. 9, 10 and 11 may be reduced by 10 per cent.

2. **Allowance for height of platform.**—If the draught desired is not greater than 0,7D (D being measured to the uppermost continuous deck) all thicknesses given in the Table may be reduced by 10 per cent.

3. **Stringer angles.**—Angles connecting the deck to shell plating are to have the same thickness as required for plated decks, cols. 9, 10 and 11.

TABLE 22 END BULKHEADS OF SUPERSTRUCTURES

Stiffeners spaced 760 mm. apart

BULKHEADS AT THE FORE END OF BRIDGES, OF UNPROTECTED POOPS THE LENGTH OF WHICH IS 0,4L OR MORE AND OF ALL POOPS PROTECTING MACHINERY OPENINGS

LENGTH L	BULB ANGLE STIFFENERS	RIVETS IN END LUGS		PLATING
		Number	Diameter	
Metres	Millimetres *Modulus—centimetres³*		Millimetres	Millimetres
Under 48,8	140 × 65 × 8,5 *91,8*	3	16	7,5
48,8	150 × 75 × 9 *114*	3	16	7,5
60	165 × 75 × 8,5 *132*	4	16	7,5
70	180 × 75 × 8 *158*	4	16	8
80	180 × 75 × 10,5 *183*	4	19	9
90	200 × 75 × 9 *211*	4	19	9,5
100	200 × 75 × 11 *243*	5	19	10
110	*278*	5	19	10,5
120	230 × 90 × 11 *308*	5	19	11
130	230 × 90 × 12 *343*	5	19	11
140	*382*	5	19	11
150	250 × 90 × 12 *424*	5	19	11
160	*472*	6	19	11
170	280 × 90 × 12 *518*	6	19	11

BULKHEADS OF POOPS PARTIALLY PROTECTED OR LESS IN LENGTH THAN 0,4L AND NOT PROTECTING MACHINERY OPENINGS

LENGTH L	ANGLE STIFFENERS	RIVETS IN END LUGS		PLATING
		Number	Diameter	
Metres	Millimetres *Modulus—centimetres³*		Millimetres	Millimetres
Under 45,75	75 × 65 × 7,5 *16,4*	2	16	6
45,75	90 × 65 × 8 *23*	2	16	6
60	100 × 75 × 8,5 *30,5*	2	16	6,5
75	120 × 75 × 8,5 *40,5*	2	16	7,5
90	130 × 75 × 9 *50,5*	3	16	8
105	150 × 75 × 9 *67*	3	16	8,5
120	150 × 75 × 11,5 *83*	3	19	9,5
135	180 × 90 × 10 *101*	3	19	9,5
150	180 × 90 × 11,5 *120*	4	19	9,5
165	180 × 90 × 12,5 *127*	4	19	9,5

BULKHEADS AT AFTER ENDS OF BRIDGES AND FORECASTLES

LENGTH L	ANGLE STIFFENERS	PLATING
Metres	Millimetres *Modulus—centimetres³*	Millimetres
Under 45,75	65 × 65 × 6,5 *9,8*	5
45,75	75 × 65 × 7 *14,8*	5
75	90 × 75 × 7,5 *21*	6
105	100 × 75 × 8 *29*	7
120	100 × 75 × 10 *35*	7,5
122 and above	100 × 75 × 10,5 *36,1*	7,5

Stiffeners to overlap, and be riveted to, boundary angles

NOTES.—TABLE 22

1. **Correction for spacing of stiffeners.**—If the spacing of stiffeners differs from 760 mm., modulus of stiffeners is to be modified in direct proportion.

If the spacing of the stiffeners is greater than 760 mm., the thickness of plating is to be increased at the rate of 0,5 mm. for every 100 mm. increase in spacing.

2. **Allowance for height of platform.**—When the draught d does not exceed 0,7D, D being measured to the uppermost continuous deck, the scantlings given in the Table may be modified as follows:—

THICKNESS OF PLATING.

Where L = 60 metres or less, thickness may be 90 per cent of Table thickness.

Where L = 120 metres or above, thickness may be 85 per cent of Table thickness.

MODULUS OF STIFFENERS.

Where L = 60 metres or less, modulus may be 75 per cent of Table modulus.

Where L = 120 metres or above, modulus may be 70 per cent of Table modulus.

For intermediate lengths the percentage may be obtained by interpolation.

3. Bulkheads at the fore ends of bridges which do not cover deck openings are to have plating as required by the Table, but the modulus of the stiffeners may be reduced by 10 per cent.

4. Particulars of sections and moduli are given in Table 56.

DECKHOUSES

TABLE 23
(SEE CONTINUATION)

LOWER TIER

Stiffeners spaced 760 mm. apart

LENGTH L	FRONTS			SIDES			CORRECTION PER 0,3 METRE DIFFERENCE IN DRAUGHT (*See* NOTE 1)	
		STIFFENERS	PLATING		STIFFENERS	PLATING	STIFFENERS	PLATING
Metres		Millimetres *Modulus—centimetres*³	Millimetres		Millimetres *Modulus—centimetres*³	Millimetres	Per Cent	Per Cent
60	ANGLES	100 × 75 × 10,5 *36,5*	6,5	ANGLES	90 × 75 × 8 *22,7*	6,5	10	6
90		130 × 75 × 8,5 *47,8*	7		100 × 75 × 7,5 *26,8*	6,5	25	8
120		130 × 75 × 11 *61,1*	7,5		100 × 75 × 9 *32,2*	7	40	10
150		150 × 75 × 11,5 *84,5*	8		120 × 75 × 8,5 *42,5*	7,5	50	11
180		*111*	8,5		140 × 75 × 8,5 *55,2*	8	50	12

UPPER TIER

Stiffeners spaced 760 mm. apart

LENGTH L	FRONTS			SIDES			CORRECTION PER 0,3 METRE DIFFERENCE IN DRAUGHT (*See* NOTE 1)	
		STIFFENERS	PLATING		STIFFENERS	PLATING	STIFFENERS	PLATING
Metres		Millimetres *Modulus—centimetres*³	Millimetres		Millimetres *Modulus—centimetres*³	Millimetres	Per Cent	Per Cent
60	ANGLES	75 × 65 × 6,5 *13,8*	6	ANGLES	65 × 65 × 6,5 *11,4*	6	10	5
90		75 × 65 × 8,5 *17,9*	6		75 × 65 × 7 *14,5*	6	15	6
120		90 × 75 × 7,5 *22,5*	6,5		75 × 75 × 9 *19,2*	6	20	7
150		100 × 75 × 8,5 *30,3*	7		90 × 75 × 8,5 *24,9*	6,5	25	8
180		120 × 75 × 8 *40,0*	7,5		100 × 75 × 9 *32,0*	7	30	9

For notes see page 133

TABLE 23
(CONTINUATION)

BEAMS WITH PLATED DECK

Spaced 760 mm. apart

LENGTH L	SPAN METRES					
	3		4,5		6	
Metres	Millimetres *Modulus—centimetres³*					
60	ANGLES	75 × 65 × 6,5 *13,9*	ANGLES	100 × 75 × 9 *31,5*	ANGLES	140 × 75 × 8,5 *55,5*
90		90 × 75 × 7 *21,0*		120 × 75 × 8 *40,1*		150 × 75 × 9 *64,7*
120		100 × 75 × 8 *27,3*		130 × 75 × 8,5 *48,6*	BULB ANGLES	140 × 65 × 7 *80,8*
150		100 × 75 × 9 *32,0*		130 × 75 × 10 *57,7*		140 × 65 × 8,5 *89,5*
180		120 × 75 × 8 *40,5*		150 × 75 × 9 *68,1*		150 × 75 × 7,5 *99,1*

DECK PLATING

ABOVE DECKHOUSES

LENGTH L	AREA OF DECK ABOVE LONG HOUSES—PERCENTAGE OF DECK AREA OF STRENGTH DECK ASSUMING TWO DECKS FITTED	MINIMUM THICKNESS OF DECK PLATING (*See* NOTE 9)	
		UNSHEATHED	SHEATHED
1	2	3	4
Metres	Per Cent	Millimetres	Millimetres
60	60	6	5
90	50	6,5	5,5
120	40	6,5	6
150	35	7	6
165	30	7,5	6,5

For notes see page 133

NOTES.—TABLE 23

1. **Draught.**—The Table is directly applicable when the ratio d/D = 0,70, D being measured to the deck upon which the lowest tier of deckhouses is situated.

If the draught is $\frac{\text{greater}}{\text{less}}$ than that corresponding to the above ratio the modulus of the stiffeners and the thickness of the plating of the deckhouse fronts and sides are to be $\frac{\text{increased}}{\text{reduced}}$ by the percentages given in this Table, subject to a maximum increase of 100 per cent and a maximum reduction of 20 per cent in modulus and subject to a maximum reduction of 10 per cent in the thickness of the plating.

2. **Spacing of stiffeners.**—If the spacing of the stiffeners differs from 760 mm., the modulus of the stiffeners is to be modified in direct proportion. The thickness of the plating is to be increased at the rate of 0,5 mm. for every 150 mm. increase in spacing.

3. **Single tier deckhouses.**—For deckhouses not having an upper tier of houses the modulus of stiffeners of the sides and aft end may, after correction for draught, be reduced by 15 per cent except where d/D exceeds 0,70.

4. **Breadth of deckhouse fronts.**—The Table is directly applicable, subject to the above corrections, to deckhouse fronts which are 0,75B or more in breadth.

When the breadth of a partially protected house front is 0,25B or less, the scantlings may be as required for sides; when the breadth is intermediate between these limits the scantlings may be obtained by interpolation.

5. **Flush deck ships, and those with forecastles, or forecastles and poops, having minimum freeboards.**—The modulus of stiffeners at the fronts of houses in these ships is, after correction, to be increased by 100 per cent, and two webs are to be arranged.

The corrected thickness of the front plating is to be increased 5 per cent.

6. **After ends of houses.**—The modulus of the stiffeners is to be 70 per cent of that of the side stiffeners and the thickness of the plating is to be 90 per cent of that of the side plating based on 760 mm. spacing. Unprotected deckhouses at after ends of ships will be specially considered.

7. **End connections of stiffeners.**—Stiffeners at fronts of deckhouses are to be lugged except at the upper tier when L is less than 152 metres. Stiffeners at sides of lower tier are to be bracketed if there are two tiers, and lugged if there is only one tier; those at upper tiers are to be lugged when L exceeds 152 metres. Stiffeners at aft ends of deckhouses may be unattached. If stiffeners are welded to the deck, brackets may be omitted, provided the section modulus of the stiffeners is increased by 20 per cent.

8. **Beams.**—The Table is directly applicable to the beams of a lower deckhouse having superimposed houses. If there are no superimposed houses the modulus of the beam may be reduced by 20 per cent.

The modulus of the beams of the upper tier may be 20 per cent less than required by the Table and if there is a third tier the beams of that tier may be 40 per cent less than required by the Table.

If the beam spacing differs from 760 mm. the modulus of the beams is to be modified in direct proportion.

9. **Deck plating above houses.**—Where the length of a deckhouse exceeds 0,15L, deck plating of the sectional area derived from the Table is to be fitted at the top of the house.

The two decks referred to in col. 2 are the decks of the main hull as used in Table 18.

If there are two tiers of houses the sectional area of the top of each may be 80 per cent of the area derived from the Table, or alternatively the top of the upper tier may be 75 per cent, and of the lower tier 100 per cent of that area.

The minimum thicknesses of plating given in cols. 3 and 4 apply to decks outside deckhouses and outside line of openings; within the line of openings the thicknesses may be reduced by 10 per cent. Inside deckhouses the thicknesses may be reduced by a further 10 per cent.

The thickness of unsheathed plating (col. 3) is to be increased by 0,5 mm. for each 150 mm. increase of spacing above 915 mm.

10. Where the height of deckhouses exceeds 2,75 metres the scantlings will be specially considered.

11. **Exposed machinery casings.**—The thickness of the plating and the modulus of the stiffeners are to be 20 per cent greater than those for deckhouses in the same position.

12. Particulars of sections and moduli are given in Table 56.

BREADTH B	BEAM SPACING	CORRECTION FACTOR K	UNSUPPORTED SPAN METRES						
			2	2,5	3	3,5	4	4,5	5
Metres	Millimetres		Millimetres Modulus—centimetres³						
7	525	1,20	75×65×8 *17,0*	75×65×9,5 *20,0*	90×75×8 *23,0*	90×75×9 *26,0*	100×75×8,5 *30,0*		
8	550	1,20	75×65×9 *19,0*	90×75×7,5 *22,0*	90×75×8,5 *25,0*	90×75×9,5 *28,5*	100×75×9,5 *33,0*		
9	570	1,20	90×75×7,5 *21,5*	90×75×8,5 *24,5*	90×75×9,5 *28,0*	100×75×9 *32,0*	100×75×10,5 *36,0*	100×75×12 *41,5*	
10	590	1,20	90×75×8,5 *25,0*	90×75×9,5 *28,0*	100×75×9 *32,0*	100×75×10,5 *36,0*	100×75×12 *41,5*	120×75×10 *48,0*	120×75×11,5 *55,0*
11	610	1,20		100×75×10 *35,0*	100×75×11 *39,0*	120×75×9 *44,0*	120×75×10,5 *51,0*	150×75×8 *59,0*	150×75×9,5 *69,0*
12	630	1,20		120×75×9,5 *45,5*	120×75×10,5 *50,0*	120×75×11,5 *56,0*	150×75×8,5 *63,5*	150×75×10 *74,0*	150×75×12 *87,5*
13	650	1,20			150×75×9 *65,0*	150×75×9,5 *71,0*	150×75×11 *80,0*	150×75×12,5 *92,0*	150×75×8,5 *106*
14	675	1,20			150×75×11,5 *85,0*	*94,0*	150×75×8 *104*	150×75×9,5 *117*	165×75×8,5 *132*
15	695	1,20			150×75×8,5 *106*	150×75×9,5 *117*	165×75×8,5 *129*	165×75×*10* *144*	180×90×8,5 *161*
16	715	1,19			*131*	*144*	180×90×8 *157*	180×90×9,5 *172*	180×90×11 *188*
17	735	1,16				180×90×9,5 *171*	180×90×10,5 *184*	180×90×11,5 *199*	*216*
18	755	1,13				180×90×11,5 *196*	*210*	200×90×10 *226*	200×90×11,5 *243*
19	775	1,10				*223*	200×90×11 *237*	200×90×12 *253*	200×90×13 *271*
20	800	1,06				200×90×11,5 *246*	200×90×12,5 *261*	*278*	*297*
21	820	1,03				*266*	*282*	*301*	230×90×11 *321*
22	840	1,00				*281*	*300*	230×90×11 *320*	230×90×12 *342*
23	860	1,00				*293*	*313*	230×90×11,5 *335*	230×90×13 *359*
24	880	1,00				*304*	230×90×11 *325*	230×90×12,5 *347*	*372*

ANGLES

BULB ANGLES

NOTES.—TABLE 24

1. **Application to various decks.**—(*a*) The modulus given in the Table applies to weather deck beams in ships having a ratio of d/D not exceeding 0,7 (D being measured to the uppermost continuous deck) with the exception of the following :—

(1) Single deck ships – – – (*see* (*d*))
(2) Short bridges and poops – – (*see* (*f*))
(3) Forecastle decks – – – (*see* (*g*))
(4) The forward 0,12L of weather decks – (*see* (*g*))

(*b*) When d/D is 0,85 or greater the modulus for weather deck beams (except as qualified by (*d*) to (*g*)) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between 0,7 and 0,85 the correction factor is to be found by interpolation between 1,0 for d/D = 0,7 and the Table factor K for d/D = 0,85.

(*d*) **Single deck ships.** The modulus is to be obtained in accordance with the above notes and increased by 20 per cent.

(*e*) **Bridges forming an effective superstructure** as defined in D 206. The modulus is to be taken directly from the Table without the use of the factor K.

(*f*) **Short bridges and poops.** The modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

(*g*) **Forecastles and weather decks.** For the forward 0,075L the Table modulus is to be multiplied by the factor 1,2K irrespective of draught. Between 0,075L and 0,12L from forward, the Table modulus is to be multiplied

UNSUPPORTED SPAN METRES							CORRECTION FACTOR K	BEAM SPACING	BREADTH B
5,5	6	6,5	7	7,5	8				
Millimetres *Modulus—centimetres³*								Millimetres	Metres
						ANGLES	1,20	525	7
						ANGLES	1,20	550	8
						ANGLES	1,20	570	9
						ANGLES	1,20	590	10
150 × 75 × 11 *82,0*						ANGLES	1,20	610	11
150 × 75 × 8 *102*	150 × 75 × 9,5 *118*					BULB ANGLES	1,20	630	12
150 × 75 × 10 *122*	165 × 75 × 9,5 *141*	180 × 75 × 8,5 *164*				BULB ANGLES	1,20	650	13
165 × 75 × 10,5 *150*	180 × 75 × 9 *170*	180 × 75 × 11 *194*	*224*			BULB ANGLES	1,20	675	14
180 × 90 × 10 *178*	180 × 90 × 11,5 *198*	*220*	200 × 90 × 11,5 *248*			BULB ANGLES	1,20	695	15
206	200 × 90 × 10 *227*	200 × 90 × 11,5 *250*	*279*	*308*	230 × 90 × 12 *341*	BULB ANGLES	1,19	715	16
200 × 90 × 10,5 *234*	200 × 90 × 12 *255*	*280*	*309*	230 × 90 × 12 *340*	*376*	BULB ANGLES	1,16	735	17
200 × 90 × 12,5 *262*	*283*	*309*	230 × 90 × 12 *340*	*374*	250 × 90 × 11,5 *412*	BULB ANGLES	1,13	755	18
291	*314*	230 × 90 × 12 *340*	*373*	250 × 90 × 11,5 *409*	250 × 90 × 13 *448*	BULB ANGLES	1,10	775	19
230 × 90 × 11 *318*	230 × 90 × 12 *342*	*371*	250 × 90 × 11,5 *407*	250 × 90 × 13 *445*	*487*	BULB ANGLES	1,06	800	20
230 × 90 × 12 *343*	*370*	250 × 90 × 11 *402*	250 × 90 × 13 *440*	*480*	*523*	BULB ANGLES	1,03	820	21
366	*396*	250 × 90 × 12,5 *430*	*470*	*509*	280 × 90 × 12,5 *549*	BULB ANGLES	1,00	840	22
384	250 × 90 × 11,5 *414*	250 × 90 × 13,5 *448*	*489*	*528*	280 × 90 × 13,5 *568*	BULB ANGLES	1,00	860	23
398	250 × 90 × 12,5 *428*	250 × 90 × 14 *464*	*506*	280 × 90 × 12 *545*	280 × 90 × 14 *586*	BULB ANGLES	1,00	880	24

NOTES.—TABLE 24 *(concluded)*

by the factor K, irrespective of draught.

2. **Span** for use in the Table is to be measured in metres from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. **Corrections to modulus of beams.**

FOR BEAM SPACING.

If the spacing at any point differs from that given in the Table the modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers respectively, but need not exceed the modulus of beams derived from Table 25 and note 3 to that Table.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted the modulus of the beam is to be increased by 30 per cent for use in Table 56.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

6. **Timber Deck Cargoes.** Where timber load lines are to be assigned the Table Modulus is to be multiplied by the factor K, irrespective of draught. In single deck ships the increase of 20 per cent is to be applied.

TABLE 25

BEAMS AT CARGO AND

BREADTH B	BEAM SPACING	CORRECTION FACTOR C		UNSUPPORTED SPAN METRES 2	2,5	3	3,5	4	4,5	5
Metres	Millimetres			Millimetres *Modulus—centimetres*³						
7	525	0,50	ANGLES	75×65×10,5 *22,0*	90×75×10,5 *31,0*	100×75×11,5 *41,0*	120×75×10,5 *51,0*			
8	550	0,50	ANGLES	75×65×10,5 *22,0*	90×75×11 *32,0*	120×75× 9 *43,0*	130×75× 9,5 *55,0*	140×75×10,5 *67,0*		
9	570	0,50	ANGLES		100×75× 9,5 *33,5*	120×75× 9,5 *46,0*	130×75×10,5 *59,0*	150×75×10 *72,0*	*86,0*	
10	590	0,50	ANGLES		100×75×10 *35,5*	120×75×10 *49,0*	130×75×11,5 *64,0*	150×75×11 *79,0*	150×75× 7 *95,0*	
11	610	0,50	ANGLES		100×75×10,5 *37,5*	120×75×11 *53,0*	150×75× 9,5 *69,5*	150×75×12 *87,0*	150×75× 8,5 *107*	165×75× 8,5 *129*
12	630	0,50	ANGLES		120×75× 8 *40,0*	130×75×10 *57,0*	150×75×10,5 *76,0*	150×75× 7 *95,5*	150×75×10 *119*	165×75×10 *146*
13	650	0,53	ANGLES		120×75× 8,5 *42,5*	130×75×11 *62,0*	150×75×11,5 *83,5*	150×75× 8,5 *106*	165×75× 8,5 *132*	180×75× 8,5 *164*
14	675	0,57	ANGLES		120×90× 9,5 *45,5*	130×90×12 *68,0*	150×90×12,5 *92,0*	*118*	*147*	180×90×10,5 *183*
15	695	0,62	ANGLES		120×90×10 *48,0*	150×90×10 *74,0*	150×90×14 *101*	*129*	180×90× 8,5 *162*	*201*
16	715	0,66	ANGLES		120×90×10,5 *51,0*	150×90×11 *79,5*	180×90×10,5 *110*	*142*	180×90×10 *178*	*219*
17	735	0,70	BULB ANGLES				*121*	180×90× 8 *157*	180×90×11,5 *196*	200×90×11 *237*
18	755	0,74	BULB ANGLES				*134*	180×90× 9,5 *172*	*213*	200×90×12 *255*
19	775	0,78	BULB ANGLES				*149*	180×90×10,5 *188*	200×90×10,5 *230*	200×90×13 *272*
20	800	0,82	BULB ANGLES				180×90× 9 *169*	*208*	200×90×11,5 *250*	*291*
21	820	0,86	BULB ANGLES				180×90×11 *190*	200×90×10 *228*	200×90×13 *268*	*308*
22	840	0,90	BULB ANGLES					200×90×12 *256*	*292*	230×90×11 *328*
23	860	0,90	BULB ANGLES						*316*	230×90×12,5 *349*
24	880	0,90	BULB ANGLES						230×90×12 *342*	*370*

NOTES.—TABLE 25

1. **Application to various decks.**—(*a*) Cargo decks. The modulus of the beams is to be determined directly from the Table and corrected as required below.

(*b*) **Accommodation decks.** The modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. **Span** for use in the Table is to be measured from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. **Corrections to modulus of beams.**

FOR BEAM SPACING.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

TABLE 25

UNSUPPORTED SPAN METRES 5,5	6	6,5	7	7,5	8		CORRECTION FACTOR C	BEAM SPACING	BREADTH B
Millimetres *Modulus—centimetres*³								Millimetres	Metres
						ANGLES	0,50	525	7
							0,50	550	8
							0,50	570	9
							0,50	590	10
165 × 75 × 10,5 *152*							0,50	610	11
180 × 75 × 10 *179*	*212*						0,50	630	12
202	200 × 90 × 11 *240*	*279*					0,53	650	13
200 × 90 × 10 *225*	200 × 90 × 13 *268*	*311*	230 × 90 × 13 *358*				0,57	675	14
200 × 90 × 11,5 *246*	*291*	230 × 90 × 11,5 *336*	*388*	250 × 90 × 13 *438*			0,62	695	15
200 × 90 × 13 *265*	*310*	230 × 90 × 13 *356*	250 × 90 × 11,5 *407*	250 × 90 × 14 *458*	*510*	BULB ANGLES	0,66	715	16
283	230 × 90 × 11,5 *328*	*375*	250 × 90 × 12 *426*	*476*	*532*		0,70	735	17
300	230 × 90 × 12 *345*	*392*	250 × 90 × 13 *443*	*494*	280 × 90 × 12,5 *549*		0,74	755	18
317	230 × 90 × 13 *361*	250 × 90 × 11,5 *407*	250 × 90 × 14 *458*	*509*	280 × 90 × 13 *566*		0,78	775	19
230 × 90 × 11,5 *334*	*377*	250 × 90 × 12 *423*	*474*	*526*	280 × 90 × 14 *583*		0,82	800	20
230 × 90 × 12,5 *350*	*391*	250 × 90 × 12,5 *437*	*487*	280 × 90 × 12 *540*	280 × 90 × 14,5 *598*		0,86	820	21
368	250 × 90 × 11,5 *409*	250 × 90 × 13,5 *454*	*505*	280 × 90 × 13 *558*	*616*		0,90	840	22
385	250 × 90 × 12 *425*	250 × 90 × 14 *468*	*520*	280 × 90 × 13,5 *574*	*632*		0,90	860	23
250 × 90 × 11 *402*	250 × 90 × 13 *441*	*484*	*535*	280 × 90 × 14 *589*	*649*		0,90	880	24

NOTES.—TABLE 25 (*concluded*)

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height in cargo spaces differs from 2,6 metres, modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, the modulus is to be increased by 30, 60 and 90 per cent of the beam modulus required for a 2,6 metres 'tween deck for, one two or three tiers respectively. For accommodation decks the increase in the modulus for hanging cargo is to be the same as required above for cargo decks.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted, the modulus of the beam is to be increased by 30 per cent for use in Table 56.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

TABLE 26

LONGITUDINALS AT WEATHER DECKS

LENGTH L	SPACING OF LONGITUDINALS	CORRECTION FACTOR K	UNSUPPORTED SPAN METRES				
			2	2,5	3	3,5	
Metres	Millimetres		Millimetres *Modulus—centimetres³*				
50	705	1,20	120×75× 9,5 *46,5*	130×75× 9,5 *55*			ANGLES
55	715	1,20	120×75×10 *49*	130×75×10 *57,5*			
60	725	1,20	130×75× 9 *51,5*	130×75×10,5 *60*			
65	735	1,20	130×75× 9,5 *54*	130×75×11 *62,5*			
70	745	1,20	130×75×10 *57*	130×75×11,5 *65*			
75	755	1,20	130×75×10,5 *59,7*	130×75×12 *66,9*			
80	765	1,20	130×75×11 *62,5*	150×75× 9,5 *70,4*			
85	775	1,20	130×75×11,5 *65*	150×75×10 *73*	150×75×11 *81,2*		
90	785	1,20	140×75×10,5 *67,6*	150×75×10,5 *76,4*	*84,1*	*94,1*	BULB ANGLES
95	795	1,20	150×75× 9,5 *71*	150×75×11 *82,4*	*92,7*	150×75× 8 *105*	
100	805	1,20	150×75×10 *75*	*89,2*	150×75× 8 *103*	150×75× 9,5 *118*	
105	815	1,20	150×75×10,5 *79*	150×75× 7 *96,5*	150×75× 9 *114*	165×75× 8,5 *131*	
110	825	1,20	150×75×11 *82,8*	150×75× 8 *103*	150×75×10,5 *124*	165×75×10 *145*	
115	835	1,18	*86,8*	150×75× 8,5 *110*	165×75× 8,5 *134*	180×90× 8 *158*	
120	845	1,17	*90,8*	150×75× 9,5 *118*	165×75×10 *144*	180×90× 9 *171*	
125	855	1,15	*94,5*	150×75×10,5 *125*	165×75×10,5 *154*	180×90×10,5 *185*	
130	865	1,13		165×75× 8,5 *132*	180×90× 8,5 *165*	180×90×11,5 *198*	
135	875	1,12		165×75× 9 *139*	180×90× 9,5 *174*	*211*	
140	885	1,10		165×75×10 *145*	180×90×10,5 *185*	*224*	
145	895	1,08		165×75×10,5 *152*	180×90×11 *195*	200×90×11 *238*	
150	905	1,07		180×90× 8 *159*	*205*	200×90×11,5 *252*	
155	915	1,05		180×90× 9 *166*	*215*	200×90×12,5 *265*	

For notes see page 139

NOTES.—TABLE 26

1. **Application to various decks.**—(*a*) The modulus given in the Table applies to weather deck longitudinals, outside the line of deck openings, in ships having a ratio of d/D not exceeding 0,7 (D being measured to the uppermost continuous deck) with the exception of the following:—

Short bridges ... ... (*see* (*e*))

(*b*) When d/D is 0,85 or greater the modulus for weather deck longitudinals (except as qualified by (*d*) to (*h*)) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between 0,7 and 0,85 the correction factor is to be found by interpolation between 1,0 for d/D=0,7 and the Table factor K for d/D=0,85.

(*d*) **Bridges forming an effective superstructure** as defined in D 206. The modulus is to be taken directly from the Table without the use of the factor K.

(*e*) **Short bridges.** The modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

(*f*) Outside the line of openings the modulus derived as above is to be maintained for 0,4L amidships and may be gradually reduced to 70 per cent of the midships value at 0,1L from the after end and to 85 per cent at 0,12L from the fore end.

(*g*) Within the line of openings abaft 0,12L from forward the modulus may be 70 per cent of that required outside the line of openings amidships.

(*h*) For the forward 0,075L of forecastles and weather decks, the Table modulus is to be multiplied by the factor 1,2K irrespective of draught. Between 0,075L and 0,12L from forward the Table modulus is to be multiplied by the factor K irrespective of draught.

2. **Span** for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. **Corrections to modulus of longitudinals.**

FOR SPACING OF LONGITUDINALS.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the longitudinals carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers, respectively, but need not exceed the modulus of longitudinals derived from Table 27 and note 3 to that Table.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

TABLE 27

LONGITUDINALS AT CARGO AND ACCOMMODATION DECKS

LENGTH L	SPACING OF LONGITUDINALS	CORRECTION FACTOR C	UNSUPPORTED SPAN METRES				
			2	2,5	3	3,5	
Metres	Millimetres		Millimetres *Modulus—centimetres³*				
50	705	0,50	100×75× 8 *29*	120×75× 8,5 *42*			ANGLES
55	715	0,50	100×75× 8,5 *31*	120×75× 9 *44*			
60	725	0,50	100×75× 9 *33*	120×75× 9,5 *46*			
65	735	0,50	100×75×10 *35,5*	120×75×10 *48,5*			
70	745	0,50	100×75×10,5 *38*	120×75×10,5 *51*			
75	755	0,50	120×75× 8 *41*	120×75×11 *54*			
80	765	0,50	120×75× 9 *44,5*	130×75×10 *56,7*			
85	775	0,50	120×75× 9,5 *47,6*	130×75×10,5 *60,2*	150×75×10 *73,2*		
90	785	0,54	130×75× 9 *52,1*	140×75×10 *64,6*	150×75×10,5 *77,1*	*91,1*	ANGLES
95	795	0,58	130×75×10 *56,8*	150×75× 9,5 *69,8*	*83,1*	150×75× 7 *97,1*	
100	805	0,61	140×75× 9,5 *61,7*	150×75×10 *75,3*	*89,0*	150×75× 8 *104*	
105	815	0,63	140×75×10 *66,6*	150×75×11 *81,0*	*95,0*	*111*	
110	825	0,65	150×75× 9,5 *71,6*	*86,3*	150×75× 7,5 *101*	150×75× 9,5 *117*	
115	835	0,67	150×75×10,5 *76,6*	*91,9*	150×75× 8,5 *107*	150×75×10,5 *124*	
120	845	0,69	150×75×11 *81,4*	150×75× 7 *97,2*	150×75× 9 *113*	*130*	
125	855	0,71	*86,0*	150×75× 8 *103*	150×75×10 *120*	165×75× 9 *137*	BULB ANGLES
130	865	0,73		150×75× 8,5 *109*	150×75×10,5 *126*	165×75× 9,5 *143*	
135	875	0,75		150×75× 9 *113*	165×75× 8,5 *131*	165×75×10 *149*	
140	885	0,77		150×75× 9,5 *119*	165×75× 9 *137*	180×90× 8 *156*	
145	895	0,79		150×75×10,5 *124*	165×75× 9,5 *143*	180×90× 8,5 *162*	
150	905	0,81		*130*	*149*	180×90× 9 *169*	
155	915	0,84		*136*	180×90× 8 *156*	180×90× 9,5 *176*	

For notes see page 141

NOTES.—TABLE 27

1. **Application to various decks.**—(*a*) For all cargo decks the modulus of the deck longitudinals is to be determined directly from the Table and corrected as required below.

(*b*) **Accommodation decks.** The modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. **Span** for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. **Corrections to modulus of longitudinals**

FOR SPACING OF LONGITUDINALS.

If the spacing at any point differs from the spacing given in the Table modulus is to be modified in direct proportion.

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height in cargo spaces differs from 2,6 metres modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the longitudinals carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, the modulus is to be increased by 30, 60 and 90 per cent of the modulus of longitudinal required for a 2,6 metres 'tween deck for one, two or three tiers respectively. For accommodation decks the increase in the modulus for hanging cargo is to be the same as required above for cargo decks.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

TABLE 28

(SEE CONTINUATION)

BEAM KNEES AND END BRACKETS OF DECK LONGITUDINALS

1. **Beam knees.** At decks where the hold frames terminate, and at the lower deck in the panting region, the dimensions of beam knees are to be based on the modulus of frame or beam, whichever is greater. At all other decks, except as indicated in 5 below, the dimensions are to be based on the modulus of the beam.

Knees are to be flanged when the modulus exceeds 590 cm.^{3} and the width of the flange in millimetres is not to be less than $2{,}09\sqrt{\text{modulus}}$ with a minimum of 50 mm.

The thickness in millimetres of unflanged knees is not to be less than $4 + 0{,}314\sqrt{\text{modulus}}$ and of flanged knees $2 + 0{,}314\sqrt{\text{modulus}}$ with a minimum of 7 mm.

2. **Riveted beam knees.**

(*a*) Rivet diameter, d, is to be based on modulus as follows:—

Modulus—cm.^{3}	d—mm.
Below 115	16
115 – 295	19
Above 295	22

(*b*) The number of rivets, N, in each overlap is not to be less than $1 + \frac{\sqrt{\text{modulus}}}{4}$ to the nearest whole number with a minimum of four. Rivets are not to be spaced less than 3½ diameters nor more than 7 diameters apart.

(*c*) The minimum length of overlap in millimetres is given by 3,5 d × N.

The depth of the knee below the bottom of the beam is not to be less than the depth of the beam.

3. **Welded beam knees.**

(*a*) The length of overlap on beam or frame in millimetres is not to be less than $20{,}8\sqrt{\text{modulus}} - 51$ with a minimum of 165 millimetres.

Where the modulus does not exceed 590 cm.^{3} the length of a flanged knee may be 85% of that obtained from this formula with a minimum of 140 millimetres.

The depth of the knee below the bottom of the beam is not to be less than the depth of the beam.

(*b*) The area of weld in square centimetres is not to be less than

$2{,}4\sqrt{\text{modulus}} - 19{,}5$ when modulus < 345

and $1{,}12\sqrt{\text{modulus}} + 4{,}5$ when modulus ≥ 345

The area of weld is defined as the product of throat thickness and length of weld. The throat thickness is not to be less than that required by Notes 5 and 6, Table 52 G.

4. **Longitudinal Framing.**

(*a*) *Frame brackets.* Where the deck is framed longitudinally the brackets connecting the side frames to the deck clear of transverses are to be in accordance with the above requirements based on the modulus of the frame, but the horizontal arm of the bracket is to be extended to a longitudinal.

(*b*) *End brackets of deck longitudinals.* Where deck longitudinals are cut at transverse bulkheads, the minimum sectional area of the bracket at the end of the longitudinal, and also the area of weld connection, are to be equal to the sectional area of the longitudinal.

The depth of the bracket below the longitudinal is to be at least equal to the depth of the longitudinal.

5. **Knees used as frame straps.**

(*a*) The number of rivets in the lower frame is to be not less than $1 + \frac{\sqrt{\text{modulus}_{LF}}}{4}$ to the nearest whole number with a minimum of four. (Modulus_{LF} is the modulus of the lower frame.)

(*b*) The number of rivets in the upper frame is not to be less than $\frac{\sqrt{\text{modulus}_{UF}}}{4}$ to the nearest whole number with a minimum of three for butted or overlapped frames. (Modulus_{UF} is the modulus of the upper frame.)

(*c*) Where butts of frames are welded, the total number of rivets in the combined frame arm is not to be less than $1 + \frac{\sqrt{\text{modulus}_{LF}}}{4}$ to the nearest whole number with not less than two rivets in each of the upper and lower frames.

(*d*) In no case is the total of the rivets in the upper and lower frames to be less than $1 + \frac{\sqrt{\text{modulus}_B}}{4}$ where modulus_B is the modulus of the beam.

(*e*) The riveting or welding of the arm to the beam, and the overlap on the beam, are to be as required by paragraphs (2) or (3) above. The modulus to be used is that of the beam or lower frame, whichever is greater.

(*f*) The welding of the knee to the upper or lower frame is to be in accordance with paragraph 3(*b*) using the modulus of the upper or lower frame as appropriate.

(*g*) The minimum length of overlap on the lower frame in millimetres is to be $3{,}5\ d \times N$ for riveted knees or $20{,}8\sqrt{\text{modulus}_{LF}} - 51$ for welded knees, with a minimum of 165 millimetres.

(*h*) For butted or lapped frames the overlap on the 'tween deck frame is not to be less than $3{,}5\ d \times N$ for riveted knees or $20{,}8\ \sqrt{\text{modulus}_{UF}} - 51$ for welded knees, with a minimum of 165 millimetres.

(*i*) Where the frames are butted the thickness of beam knee, if required to be flanged, is to be increased 2 millimetres or, where modulus_{LF} or modulus_B (whichever is greater) does not exceed 590 cm.^3 it is to be flanged.

TABLE 29
(SEE CONTINUATION)

DECK GIRDERS

NUMERAL	DEPTH OF END BRACKETS BELOW DECK	DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS								
		Millimetres 250 × 8,0	Millimetres 275 × 8,5	Millimetres 300 × 8,5	Millimetres 325 × 8,5	Millimetres 350 × 8,5	Millimetres 375 × 9,0	Millimetres 400 × 9,0	Millimetres 425 × 9,0	Millimetres 450 × 9
		REDUCTION IN FACE AREA (SQUARE CENTIMETRES) PER ONE MILLIMETRE INCREASE IN WEB THICKNESS (see also NOTE 4)								
		0,7	*0,8*	*0,9*	*1,0*	*1,0*	*1,1*	*1,2*	*1,2*	*1,3*
		FACE AREA								
	Millimetres	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cm
50	490	7,5								
100	540	20,0	16,5	13,5						
200	630	38,0	33,0	29,0	25,0	21,5				
300	720	55,5	49,0	43,5	38,5	34,0	29,5	26,5	23,5	20,5
400	790	77,0	68,0	61,0	54,5	48,5	43,5	39,0	35,0	31,5
600	870		106,0	96,0	86,5	77,5	70,0	64,5	59,0	54,0
800	940			131,0	119,5	108,5	98,5	90,5	83,5	77,0
1000	1000			165,0	151,5	138,0	126,5	117,0	107,5	100,0
1200	1060				182,5	167,5	154,5	143,0	132,0	122,5
1400	1120							170,0	156,5	146,0
1600	1180								179,5	168,5
1800	1240									191,0
2000										
2200										
2400										
2600										

For notes see page 147

DECK GIRDERS

DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS									DEPTH OF END BRACKETS BELOW DECK	NUMERAL
Millimetres 475 × 9,5	Millimetres 500 × 9,5	Millimetres 525 × 9,5	Millimetres 550 × 9,5	Millimetres 575 × 10,0	Millimetres 600 × 10,0	Millimetres 625 × 10,0	Millimetres 650 × 10,0	Millimetres 675 × 10,5		
REDUCTION IN FACE AREA (SQUARE CENTIMETRES) PER ONE MILLIMETRE INCREASE IN WEB THICKNESS (see also NOTE 4)										
1,4	*1,5*	*1,5*	*1,6*	*1,6*	*1,7*	*1,8*	*1,9*	*2,0*		
FACE AREA										
Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Millimetres	
									490	50
									540	100
									630	200
									720	300
28,0	24,5	22,0							790	400
49,0	44,5	41,0	37,5	33,5	30,5	27,5			870	600
71,0	65,0	60,5	56,0	51,5	47,5	44,0	40,5	36,5	940	800
92,5	85,5	79,5	74,5	69,0	64,0	60,0	56,0	51,5	1000	1000
113,5	105,5	99,0	93,0	86,5	81,5	75,5	71,5	66,5	1060	1200
136,0	127,0	118,5	111,5	104,0	97,5	92,5	87,0	81,5	1120	1400
157,5	147,5	138,5	130,0	122,0	115,0	108,5	103,0	96,5	1180	1600
179,5	168,0	158,0	148,5	140,0	132,0	125,0	118,5	111,5	1240	1800
	187,5	177,0	166,5	157,5	149,0	141,0	134,0	127,0		2000
			184,0	174,5	166,0	157,0	149,5	142,0		2200
						172,5	165,0	157,0		2400
										2600

For notes see page 147

TABLE 29

(SEE CONTINUATION)

DECK GIRDERS

NUMERAL	DEPTH OF END BRACKETS BELOW DECK	DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS								
		Millimetres 700 × 10,5	Millimetres 725 × 10,5	Millimetres 750 × 10,5	Millimetres 775 × 11,0	Millimetres 800 × 11,0	Millimetres 825 × 11,0	Millimetres 850 × 11,0	Millimetres 875 × 11,5	Millimetres 900 × 11,5
		REDUCTION IN FACE AREA (SQUARE CENTIMETRES) PER ONE MILLIMETRE INCREASE IN WEB THICKNESS (see also NOTE 4)								
		2,0	*2,1*	*2,2*	*2,2*	*2,3*	*2,3*	*2,4*	*2,5*	*2,5*
		FACE AREA								
50	Millimetres 490	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.	Square cms.
100	540									
200	630									
300	720									
400	790									
600	870									
800	940	33,0	30,5							
1000	1000	48,0	46,5	41,0	37,5	34,0	31,0			
1200	1060	62,0	58,0	54,5	50,0	46,5	43,5	39,5	36,5	33,0
1400	1120	76,5	72,0	68,0	63,5	59,0	55,0	52,0	48,0	44,0
1600	1180	91,0	86,0	81,5	76,5	72,0	68,0	64,0	59,5	55,0
1800	1240	105,5	100,0	95,0	89,5	84,0	80,0	75,5	71,0	66,5
2000		120,0	114,0	108,5	102,5	97,0	92,5	87,5	83,0	78,0
2200		134,5	128,0	122,0	115,5	109,5	104,5	99,5	94,5	89,0
2400		149,5	142,5	135,5	128,5	122,0	116,5	111,0	106,0	100,0
2600		163,5	156,5	149,0	141,5	135,0	129,0	123,5	118,0	111,5

For notes see page 147

NOTES.—TABLE 29

1. **Longitudinal girders.**

The numeral for use in the Table is given by :

$$l^2 \times b \times h$$

where l = the span of the girder, in metres, from pillar to pillar, or from pillar to bulkhead less half the distance between the toe of the end bracket and the bulkhead.

b = the mean width of deck, in metres, supported by the girder.

h is to be measured as follows :

(*a*) For decks on which cargo is carried h is the mean height in metres from top of beam to top of beam of the 'tween decks next above the girder.

(*b*) For decks under accommodation spaces h is 1,22 metres. (*See also* Note 1 (*e*).)

(*c*) For weather decks, except in the forward 0,12L, h is 1,22 metres if the draught does not exceed 0,7D and 1,52 metres if the draught is 0,85D or greater, with intermediate values in proportion, D being measured to the uppermost continuous deck. (*See also* Note 1 (*e*).)

(*d*) **Weather decks.** For the forward 0,075L, h is to be 1,83 metres, irrespective of draught. Between 0,075L and 0,12L from forward, h is to be 1,52 metres, irrespective of draught.

(*e*) For decks above the uppermost continuous deck h, as given in (*b*) and (*c*), may be successively reduced by 0,3 metre for each deck to a minimum of 0,46 metre.

(*f*) Where decks support a hanging cargo, such as chilled meat, in addition to deck loads, the value of h is to be increased by 0,76 metre for one tier, 1,52 metres for two tiers and 2,30 metres for three tiers.

2. **Strong hatch side coamings and end beams in 'tween decks.**

(*a*) SIDE COAMINGS.

The numeral for use in the Table is given by :

$$1{,}1 \times l^2 \times b \times h$$

where l = the length of the hatchway in metres.

b = the mean breadth in metres of deck, including hatchway, supported by the coaming.

h = the mean height in metres of 'tween decks as in note 1.

(*b*) HATCH END BEAMS.

For strong hatch end beams which are supported at the centre line and carry the hatch side coamings only, the numeral for use in the Table is given by :

$$0{,}75\ B \times l \times b \times h$$

where B = the span of the hatch end beam, in metres, measured from the centre line to the ship's side less half the distance between the toe of the bracket and the ship's side.

l, b and h are measured as in note 2 (*a*).

Where the hatch end beam supports the hatch side coaming and, in addition, an adjacent longitudinal girder in line, the numeral is given by :

$$0{,}75\ B\ (l_1 \times b_1 \times h + l_2 \times b_2 \times h)$$

where l_1, b_1 and h are measured as in note 2 (*a*) and l_2 and b_2 are measured as in note 1.

(*c*) The depth of strong hatch end beams derived from the Table is to be maintained for the full breadth of the ship.

(*d*) Strong hatch side coamings and end beams supporting deck longitudinals in association with transverses will be specially considered.

3. **Transverses supporting deck longitudinals.**

The numeral for use in the Table is given by :

$$l^2 \times b \times h$$

where l = the span, in metres, of the transverse measured from pillar to pillar or from pillar to ship's side less half the distance between the toe of the bracket and the ship's side.

b is the length of deck in metres supported by the transverses.

h is measured as in note 1.

In single deck ships the depth of the transverses is to be increased by 15 per cent.

4. The sectional area of girder flanges derived from the Table may take the form of rolled sections, or flanged girder plates, with rider plates where necessary, the depth of the girder being measured to the bottom of the web. Where the depth of beam or longitudinal notches exceeds 50 per cent of the depth of the girder or 300 mm., whichever is less, the face area is to be suitably increased. The width of the flange is not to exceed the depth of the girder.

5. For end connections and constructional details *see* D 1505 to D 1515.

For spacing of girders and transverses in the forward 0,075 L *see* D 1501.

6. **Timber Deck Cargoes.** Where timber load lines are to be assigned, h in the foregoing formulæ for weather decks is to be taken at 1,52 metres where the beam B does not exceed 15,25 metres, and 1,83 metres where the beam is 18,3 metres or over, with intermediate values in proportion. In single deck ships the depth of the transverses supporting deck longitudinals (note 3) is to be increased by 30 per cent.

DECK RUNNERS

NUMERAL	DOUBLE ANGLES		SINGLE ANGLE OR BULB ANGLE
	Millimetres		Millimetres
5	75 × 65 × 7,0	ANGLES	100 × 75 × 7,5
10	90 × 75 × 8,0		120 × 75 × 8,5
15	100 × 75 × 9,0		130 × 75 × 11,5
20	100 × 75 × 11,0		140 × 75 × 12,5
25	120 × 75 × 9,5		150 × 75 × 12,5
30	130 × 75 × 9,5	BULB ANGLES	150 × 75 × 8,5
35	130 × 75 × 11,5		150 × 75 × 10,5
40	150 × 75 × 10,0		165 × 75 × 10,0
45	150 × 75 × 11,0		180 × 75 × 9,0
50	150 × 75 × 12,0		180 × 75 × 10,5

NOTES.—TABLE 30

1. The numeral is to be determined in accordance with Table 29, note 1.
2. The runners are to be fitted with the deep flange vertical.

TABLE 31

(SEE CONTINUATION)

PILLARS

NUMERAL	LENGTH AND FORM OF PILLAR															
	Metres 2,5						Metres 3,0						Metres 4,0			
	TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		
	Outside diameter	CHANNELS	FACE PLATES	Diameter	Rivets in ends		Outside diameter	CHANNELS	FACE PLATES	Diameter	Rivets in ends		Outside diameter	CHANNELS	FACE PLATE	
	mm	mm	mm	mm	No	mm	mm	mm	mm	mm	No	mm	mm	mm	mm	
10	65× 8,0			60	2	22	75× 8,0			65	2	22	90× 8,5			
15	80× 8,5			65	2	22	90× 8,5			70	2	22	105× 9,0			
20	95× 8,5			71	2	22	100× 9,0			77	2	22	120× 9			
30	115× 9			81	2	22	120× 9,5			87	2	22	140× 9,5			
40	140× 9			88	3	22	140× 9,5			95	3	22	155×10			
60	160×10			105	3	25	170×10			115	3	25	190×10			
80	200×10			115	4	25	205×10,5			125	4	25	230×10	200× 85× 85×11		
100	215×11	200× 85× 85×11		120	4	25	225×10,5	200× 85× 85×11,5		130	5	25	240×11	220× 90× 90×11		
120	235×11,5	220× 90× 90×11		130	5	25	245×11,5	220× 90× 90×11,5		140	5	25	255×12	240× 95× 95×12		
140	255×12,5	240× 95× 95×11,5		140	6	25	255×12,5	260× 95× 95×12		150	6	25	275×12,5	260× 95× 95×14		
160	265×13,5	260× 95× 95×12,5					270×13,5	260× 95× 95×14,5					285×13,5	240× 95× 95×12	250×10	
180	300×13,5	260× 95× 95×14					300×13,5	240× 95× 95×12	250×10				300×14	240× 95× 95×12	270×11	
200	325×13,5	240× 95× 95×12	260×10,5				325×14	240× 95× 95×14	270×11				330×14	260× 95× 95×12	290×12	
250	375×14,5	240× 95× 95×12	300×13				380×14,5	260× 95× 95×12	300×13,5				385×14,5	280×100×100×13	320×14	
300	425×15	260× 95× 95×12	320×15,5				435×15	280×100×100×13	320×16				435×15,5	300×100×100×13	340×16	
350	460×15,5	280×100×100×13	340×17,5				460×16	300×100×100×13	340×18				470×16,5			
400	470×16,5						480×16,5						510×17			
450	500×17						510×17						560×17			
500	555×17						555×17,5						590×18			
550	595×18						625×18						645×18,5			
600	645×18,5						650×19						660×19,5			
650	655×19,5						675×19,5						695×20			
700	680×20						705×20						730×20,5			
750	720×20,5						740×20,5						780×20,5			

For notes see page 152

LENGTH AND FORM OF PILLAR														NUMERAL
Metres 4,0			Metres 5,0						Metres 6,0					
SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID		
Diameter	Rivets in ends		Outside diameter	CHANNELS	FACE PLATES	Diameter	Rivets in ends		Outside diameter	CHANNELS	FACE PLATES	Diameter	Rivets in ends	
mm	No.	mm	mm	mm	mm	mm	No.	mm	mm	mm	mm	mm	No.	mm	
74	2	22	95× 9,0			81	2	22	105× 9,5			95	3	22	10
81	2	22	120× 9,0			92	2	22	125× 9,5			105	3	22	15
89	2	22	135× 9,5			100	3	22	150× 9,5			110	3	22	20
100	3	22	155×10			120	3	22	170×10			135	4	22	30
110	3	22	175×10			130	4	22	190×10	200× 85× 85×11		150	4	25	40
135	4	25	215×10			155	5	25	225×10,5	220× 90× 90×11					60
145	5	25	230×11	200× 85× 85×11,5		165	6	25	245×11	240× 95× 95×12					80
155	6	25	250×11,5	240× 95× 95×12					270×11,5	260× 95× 95×12					100
160	6	25	260×12,5	260× 95× 95×13					305×12,5	280×100×100×14					120
170	6	25	280×12,5	280×100×100×14					305×13	240× 95× 95×12	250×10				140
			300×13,5	240× 95× 95×12	270×11,5				320×13,5	240× 95× 95×12	290×12,5				160
			320×14	260× 95× 95×12	290×12,5				340×14	260× 95× 95×12	300×13,5				180
			340×14	260× 95× 95×12	300×14				360×14,5	260× 95× 95×12,5	300×15,5				200
			400×14,5	300×100×100×13	340×15,5				410×15,5	300×100×100×13	340×17				250
			450×15						455×16,5						300
			490×16,5						500×17						350
			540×17						565×17						400
			565×18						585×18						450
			600×18,5						630×18,5						500
			655×18,5						665×19,5						550
			680×19,5						690×20,5						600
			705×20,5						735×21						650
			760×20,5						790×21						700
															750

For notes see page 152

TABLE 31
(CONCLUDED)

PILLARS

NUMERAL	LENGTH AND FORM OF PILLAR											
	Metres 7,0						Metres 8,0					
	TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID		
	Outside diameter	CHANNELS	FACE PLATES	Diameter	Rivets in ends		Outside diameter	CHANNELS	FACE PLATES	Diameter	Rivets in ends	
	mm.	mm.	mm.	mm.	No	mm.	mm.	mm.	mm.	mm.	No.	mm.
10				105	3	22				115	4	22
15				115	3	22				130	4	22
20	165× 9,5			125	3	22	185× 9,5			140	4	22
30	185×10	200× 85× 85×11,5		150	4	25	205×10	220× 90× 90×11,5				
40	205×10,5	200× 85× 85×12,5					215×11	240× 95× 95×12				
60	230×11	220× 90× 90×13,5					245×11	240× 95× 95×14				
80	255×11,5	240× 95× 95×13,5					260×12	260× 95× 95×14,5				
100	270×12,5	260× 95× 95×15					275×13	240× 95× 95×12	250×10			
120	290×13	220× 90× 90×12	260×11				310×13	240× 95× 95×12	270×12			
140	325×13	240× 95× 95×12	290×12,5				345×13	260× 95× 95×12	300×13			
160	335×14	260× 95× 95×12	300×14				355×14	260× 95× 95×12	310×15,5			
180	365×14	260× 95× 95×12	310×15,5				380×14,5	280×100×100×13	320×17			
200	370×15	280×100×100×13	320×17,5				400×15	300×100×100×14	330×18,5			
250	430×16						450×16					
300	470×17						490×17					
350	520×17,5						525×18					
400	585×17,5											
450	585×18,5											
500	640×19,5											
550	710×19,5											
600												
650												
700												
750												

NOTES.—TABLE 31

1. The numeral for use in the Table is to be the sum of the numerals representing the separate loads which may be transmitted to the pillar, namely :

(*a*) The numeral in respect of that proportion of the deck load, supported by a girder, hatch end beam or deck transverse, which is borne by the pillar.

(*b*) The numeral of the directly superimposed pillar, if any.

2. The numeral is to be determined by :

$$s \times b \times h$$

where s = the distance, in metres, between the centres of the two adjacent spans of girder supported by the pillar.

b = the mean width of deck, in metres, including hatchway if necessary, supported by the girders over the distance s.

h is to be measured as defined in Table 29, note 1.

3. Pillars equivalent to those shown in the Tables, of riveted or welded construction, will be accepted.

When hollow square pillars are fitted, the thickness is to be the same as that of the tubular pillar required and the side is to be 80 per cent of the diameter of the tubular pillar.

4. When solid pillars are fitted in pairs to take shifting boards, their diameter is to be 75 per cent of that required by the Table.

5. For end connections and constructional details *see* D 1516 to D 1524.

6. **Timber Deck Cargoes.** Where timber load lines are to be assigned, h is to be measured as defined in Table 29, note 6.

BULKHEAD PLATING

Stiffeners spaced 760 mm. apart on watertight bulkheads and 610 mm. apart on collision, deep tank, peak tank and oil fuel bunker bulkheads

DEPTH (*See* NOTE 1)	THICKNESS	DEPTH (*See* NOTE 1)	THICKNESS
Metres	Millimetres	Metres	Millimetres
2,2	6,5	10,5	10
3,4	7	11,75	10,5
4,6	7,5	12,95	11
5,8	8	14,15	11,5
7,0	8,5	15,35	12
8,15	9	16,55	12,5
9,35	9,5	17,75	13

NOTES.—TABLE 32

1. **Depth** is to be measured as follows :—

(*a*) **For watertight bulkheads** (D 16).—From the lower edge of the plate to the top of the bulkhead at the centre line.

(*b*) **For bulkheads of tanks** (D 19 and D 20).—From the lower edge of the plate to the top of the tank or to a point midway between the half-depth of the tank and the top of the overflow, whichever distance is greater.

2. **Correction for spacing of stiffeners.**—Where the spacing of stiffeners differs from that given in the Table the thickness of the plating is to be modified at the rate of 2 per cent for every 25 mm. of difference except that where the spacing on tank or oil bunker bulkheads exceeds 610 mm. the thickness is to be increased at the rate of 3 per cent per 25 mm. difference of spacing.

3. **Additions to thickness**, as corrected by note 2, are to be made as follows :—

(*a*) To the lowest strake of hold and tank bulkheads ... . 1 mm.

(*b*) To the lowest strake of stokehold bulkheads in coal burning ships ... ... 2,5 mm.

(*c*) Plates in limbers and at the bottom of peak bulkheads ... ... 2,5 mm.

(*d*) In way of the stern tube, plating to be increased substantially or doubled.

4. The plating of deep tank, peak tank and oil fuel bunker bulkheads in ships exceeding 46 metres in length is not to be less than 7,5 mm. after correction.

TABLE 33
(SEE CONTINUATION)

BULKHEAD STIFFENER

Spaced 610 mm. apart on collision bulkhea

LENGTH OF STIFFENER		HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER METRES					
		0	0,6	1,2	1,8	2,4	3,0
Metres		Millimetres *Modulus—centimetres*[a]					
2,4	ANGLES	100 × 65 × 7,5 *25,9*	100 × 75 × 9,5 *33,1*	100 × 75 × 10,5 *37,1*	120 × 75 × 8,5 *42,1*	130 × 75 × 9 *50,7*	140 × 75 × 9 *57,5*
2,7	ANGLES	100 × 75 × 10 *34,8*	120 × 75 × 8,5 *42,7*	130 × 75 × 8,5 *47,5*	140 × 75 × 8,5 *57,1*	150 × 75 × 9 *67,4*	150 × 75 × 10 *72,2*
3,0	ANGLES	130 × 75 × 8 *45,0*	140 × 75 × 8,5 *55,1*	150 × 75 × 8,5 *64,1*	150 × 75 × 9,5 *71,9*	140 × 65 × 8 *87,5*	150 × 75 × 8,5 *107*
3,3	ANGLES	140 × 75 × 9 *57,5*	150 × 75 × 9 *68,0*	140 × 65 × 8 *86,9*	140 × 65 × 9 *94,5*	150 × 75 × 8,5 *109*	165 × 75 × 8,5 *131*
3,6	ANGLES	150 × 75 × 9,5 *71,8*	140 × 65 × 8,5 *90,1*	150 × 75 × 8,5 *109*	150 × 75 × 9,5 *116*	165 × 75 × 8,5 *135*	180 × 75 × 8 *158*
3,9	BULB ANGLES	140 × 65 × 8,5 *92,8*	150 × 75 × 9 *112*	165 × 75 × 8,5 *131*	165 × 75 × 9 *138*	180 × 75 × 8,5 *163*	180 × 75 × 10,5 *189*
4,2	BULB ANGLES	150 × 75 × 9 *112*	165 × 75 × 8,5 *132*	180 × 75 × 8 *159*	180 × 75 × 9 *167*	180 × 75 × 11 *192*	200 × 75 × 9,5 *222*
4,5	BULB ANGLES	165 × 75 × 8,5 *132*	180 × 75 × 8 *159*	180 × 75 × 10,5 *189*	*199*	200 × 75 × 10 *227*	200 × 75 × 12 *257*
4,8	BULB ANGLES	180 × 75 × 8 *159*	180 × 75 × 10,5 *188*	200 × 75 × 9,5 *221*	200 × 75 × 10,5 *232*	200 × 90 × 12,5 *264*	*299*
5,1	BULB ANGLES	180 × 75 × 10,5 *189*	200 × 75 × 9,5 *221*	200 × 75 × 12 *257*	200 × 90 × 13 *269*	*308*	230 × 90 × 12 *344*
5,4	BULB ANGLES	200 × 75 × 9,5 *221*	200 × 75 × 12 *257*	*300*	*312*	230 × 90 × 12,5 *347*	*387*
5,7	BULB ANGLES	200 × 75 × 12 *257*	*299*	230 × 90 × 11 *325*	230 × 90 × 12,5 *352*	*390*	250 × 90 × 12,5 *439*
6,0	BULB ANGLES	*300*	230 × 90 × 12 *344*	*379*	250 × 90 × 12,5 *431*	250 × 90 × 13,5 *454*	*489*
6,3	BULB ANGLES	230 × 90 × 12 *344*	*387*	250 × 90 × 12,5 *432*	*490*	*503*	280 × 90 × 12,5 *552*
6,6	BULB ANGLES	*387*	250 × 90 × 12,5 *432*	*484*	280 × 90 × 12 *538*	280 × 90 × 13,5 *581*	*615*
6,9	BULB ANGLES	250 × 90 × 12,5 *432*	*484*	280 × 90 × 12 *538*	280 × 90 × 14 *595*	*635*	300 × 90 × 13 *665*
7,2	BULB ANGLES	*485*	280 × 90 × 12 *539*	280 × 90 × 14 *595*	*656*	300 × 90 × 13,5 *682*	300 × 90 × 15 *726*
7,5	BULB ANGLES	280 × 90 × 12 *539*	280 × 90 × 14 *595*	*656*	300 × 90 × 14,5 *713*	300 × 90 × 15,5 *743*	300 × 100 × 100 × 14 *808*
7,8	BULB ANGLES	280 × 90 × 14 *595*	*656*	300 × 90 × 14,5 *713*	*769*	300 × 100 × 100 × 14,5 *820*	320 × 100 × 100 × 13 *879*
8,1	BULB ANGLES	*656*	300 × 90 × 14 *695*	300 × 90 × 16 *754*	300 × 100 × 100 × 16 *847*	320 × 100 × 100 × 14,5 *913*	

For notes see page 161

and 760 mm. apart on other watertight bulkheads

HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER METRES						LENGTH OF STIFFENER
3,6	4,2	4,8	5,4	6,0		
Millimetres *Modulus—centimetres³*						Metres
150 × 75 × 8,5 *63,5*	150 × 75 × 9 *66,8*	150 × 75 × 10,5 *75,9*	140 × 65 × 8 *87,1*	140 × 65 × 8,5 *92,0*	BULB ANGLES	2,4
140 × 65 × 8 *86,0*	140 × 65 × 9 *93,1*	150 × 75 × 8,5 *107*	150 × 75 × 9 *112*	165 × 75 × 8 *129*		2,7
150 × 75 × 9 *112*	150 × 75 × 9,5 *116*	165 × 75 × 8,5 *131*	165 × 75 × 9 *138*	180 × 75 × 8 *158*		3,0
165 × 75 × 9 *137*	165 × 75 × 10,5 *154*	180 × 75 × 8,5 *164*	180 × 75 × 10,5 *185*	180 × 75 × 11 *194*		3,3
180 × 75 × 8,5 *165*	180 × 75 × 10,5 *188*	180 × 75 × 11 *194*	200 × 75 × 9,5 *221*	200 × 75 × 10 *230*		3,6
180 × 75 × 11 *195*	200 × 75 × 9,5 *221*	200 × 75 × 10,5 *233*	200 × 90 × 13 *268*	 *294*		3,9
200 × 75 × 10,5 *232*	200 × 75 × 12 *257*	 *285*	 *304*	230 × 90 × 11,5 *337*		4,2
200 × 90 × 13 *270*	 *299*	230 × 90 × 11 *321*	230 × 90 × 12 *345*	 *383*		4,5
 313	230 × 90 × 12 *344*	 *379*	250 × 90 × 12 *420*	250 × 90 × 13 *446*		4,8
230 × 90 × 12,5 *353*	 *389*	250 × 90 × 12,5 *438*	 *485*	 *537*		5,1
250 × 90 × 12 *422*	 *473*	 *498*	280 × 90 × 12 *547*	280 × 90 × 14,5 *598*		5,4
 485	280 × 90 × 12 *547*	280 × 90 × 14 *585*	280 × 90 × 14,5 *608*	 *656*		5,7
280 × 90 × 12 *547*	280 × 90 × 14,5 *599*	 *634*	300 × 90 × 13 *661*	300 × 90 × 14 *702*		6,0
280 × 90 × 14,5 *604*	 *656*	300 × 90 × 13,5 *674*	300 × 90 × 15 *725*	 *751*	CHANNELS	6,3
 659	300 × 90 × 14,5 *712*	300 × 90 × 15,5 *732*	300 × 100 × 100 × 14 *805*	300 × 100 × 100 × 15 *827*		6,6
300 × 90 × 15 *717*	300 × 90 × 16 *754*	300 × 100 × 100 × 14 *809*	320 × 100 × 100 × 14 *895*	320 × 100 × 100 × 15 *922*		6,9
300 × 100 × 100 × 13 *772*	300 × 100 × 100 × 14,5 *821*	320 × 100 × 100 × 14 *897*	350 × 100 × 100 × 14,5 *990*	350 × 100 × 100 × 15,5 *1019*		7,2
300 × 100 × 100 × 15,5 *845*						7,5
						7,8
						8,1

For notes see page 161

TABLE 34

(SEE CONTINUATION)

BULKHEAD STIFFENERS

Spaced 610 mm. apart on collision bulkhead

LENGTH OF STIFFENER		HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — METRES						
		0	0,6	1,2	1,8	2,4	3,0	3,6
Metres		MILLIMETRES — *Modulus—centimetres³*						
2,4	ANGLES	* 100×65×10,5 *36,1*	120×75× 9,5 *47,2*	140×75× 9 *57,9*	150×75× 9,5 *70,9*	140×65× 8,5 *91,3*	140×65× 9 *95,8*	150×75× 8 *110*
2,7	ANGLES	* 130×75× 9,5 *54,7*	140×75× 9,5 *61,7*	140×65× 8,5 *89,5*	140×65× 9 *95,4*	150×75× 8,5 *110*	150×75× 9,5 *119*	165×75× 8,5 *133*
3,0	ANGLES	* 150×75× 9,5 *71,9*	140×65× 8,5 *91,9*	150×75× 8,5 *110*	165×75× 8,5 *130*	165×75× 9 *138*	180×75× 8 *157*	180×75× 9 *167*
3,3	BULB ANGLES	140×65× 9 *94,8*	150×75× 9 *115*	165×75× 8,5 *133*	180×75× 8,5 *160*	180×75× 9 *169*	180×75×11 *193*	200×75× 9,5 *219*
3,6	BULB ANGLES	150×75× 9,5 *119*	165×75× 9,5 *142*	180×75× 8,5 *164*	180×75×11 *191*	*207*	200×75×10,5 *232*	200×90×12,5 *264*
3,9	BULB ANGLES	165×75× 8,5 *134*	180×75× 9 *167*	*199*	200×75×10 *229*	200×75×12 *255*	*296*	*314*
4,2	BULB ANGLES	180×75× 9 *168*	*201*	200×75×12 *253*	*273*	*308*	230×90×12,5 *346*	230×90×13 *361*
4,5	BULB ANGLES	*202*	200×75×11 *242*	*301*	*319*	*352*	*392*	250×90×12,5 *428*
4,8	BULB ANGLES	200×75×12 *253*	*298*	230×90×12,5 *346*	*382*	250×90×11,5 *407*	250×90×13,5 *456*	*496*
5,1	BULB ANGLES	*307*	230×90×12,5 *346*	*392*	250×90×13 *443*	*482*	*513*	280×90×13 *568*
5,4	BULB ANGLES	230×90×12,5 *349*	250×90×11 *400*	250×90×13,5 *456*	*499*	280×90×13 *560*	280×90×14,5 *596*	*652*
5,7	BULB ANGLES	*392*	250×90×13,5 *450*	*508*	280×90×13,5 *576*	*621*	300×90×13 *663*	*728*
6,0	BULB ANGLES	*474*	*508*	280×90×14 *587*	*656*	300×90×13,5 *673*	*729*	300×100×100×14,5 *812*
6,3	BULB ANGLES	*521*	280×90×14 *588*	300×90×13 *660*	300×90×14,5 *706*	*733*	300×100×100×14,5 *811*	320×100×100×14 *902*
6,6	BULB ANGLES	280×90×14 *588*	300×90×13 *660*	300×90×14,5 *707*	*758*	300×100×100×14,5 *814*	320×100×100×14,5 *903*	350×100×100×14,5 *996*
6,9	BULB ANGLES	300×90×13 *660*	300×90×15 *716*	*767*	300×100×100×15,5 *842*	320×100×100×14,5 *904*	350×100×100×14,5 *995*	
7,2	BULB ANGLES	300×90×15 *717*	300×100×100×13,5 *781*	300×100×100×16 *854*	320×100×100×15,5 *937*	350×100×100×15 *1010*		
7,5	CHANNELS	*773*	320×100×100×13 *868*	320×100×100×16 *953*	350×100×100×16 *1035*			
7,8	CHANNELS	300×100×100×16 *853*	350×100×100×14 *971*	350×100×100×16,5 *1060*				
8,1	CHANNELS	320×100×100×16 *952*	380×100×100×13 *1079*					

The ends of upper 'tween deck stiffeners marked * may be riveted to the boundary angle only without lug attachment

For notes see page 161

TABLE 34

(SEE CONTINUATION)

and 760 mm. apart on other watertight bulkheads

HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — METRES							LENGTH OF STIFFENER	
4,2	4,8	5,4	6,0	6,6	7,2	7,8		
MILLIMETRES *Modulus—centimetres³*							Metres	
150×75× 9,5 *119*	165×75× 8,5 *130*	165×75× 9 *137*	180×75× 8 *158*	180×75× 8,5 *164*	180×75× 9 *169*	180×75×10,5 *185*	2,4	BULB ANGLES
180×75× 8 *157*	180×75× 9 *168*	180×75× 9,5 *176*	180×75×11 *193*	200×75× 9,5 *218*	200×75×10 *228*	200×75×12 *252*	2,7	
180×75×11 *190*	*203*	200×75×10 *225*	200×75×12 *253*	200×90×13 *269*	*296*	*311*	3,0	
200×75×10,5 *233*	200×75×12 *255*	*273*	*307*	230×90×11 *320*	230×90×12,5 *346*	*378*	3,3	
296	*310*	230×90×12 *340*	230×90×13 *359*	*387*	250×90×11,5 *411*	250×90×12,5 *434*	3,6	
230×90×12,5 *346*	230×90×13 *360*	250×90×11 *399*	250×90×12,5 *437*	*478*	*496*	280×90×12 *538*	3,9	
250×90×11 *399*	250×90×12,5 *436*	*480*	*506*	280×90×13 *559*	280×90×14 *592*	*624*	4,2	
479	*506*	280×90×13 *560*	280×90×14 *592*	*649*	300×90×13,5 *671*	300×90×14 *697*	4,5	
517	280×90×14 *585*	*627*	300×90×13 *661*	*713*	*737*	300×100×100×14 *801*	4,8	CHANNELS
280×90×14,5 *604*	300×90×13 *659*	300×90×14,5 *706*	*733*	300×100×100×14 *805*	300×100×100×15 *830*	320×100×100×14 *900*	5,1	
300×90×13,5 *684*	*730*	300×100×100×14 *806*	300×100×100×15 *829*	320×100×100×14 *901*	350×100×100×13 *940*	350×100×100×15 *1009*	5,4	
756	300×100×100×14,5 *814*	320×100×100×14 *901*	320×100×100×15,5 *938*	350×100×100×15 *998*			5,7	
300×100×100×16 *847*	320×100×100×14,5 *905*	350×100×100×14,5 *995*	350×100×100×16,5 *1059*				6,0	
350×100×100×13 *942*	350×100×100×15,5 *1022*						6,3	
							6,6	
							6,9	
							7,2	
							7,5	
							7,8	
							8,1	

For notes see page 161

TABLE 34 (CONCLUDED) BULKHEAD STIFFENERS—LUGGED

Spaced 610 mm. apart on collision bulkheads and 760 mm. apart on other watertight bulkheads

LENGTH OF STIFFENER		HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER METRES						
		8,4	9,0	9,6	10,2	10,8	11,4	12,0
Metres		MILLIMETRES *Modulus—centimetres³*						
2,4	BULB ANGLES	*198*	200×75× 9,5 *219*	200×75×10 *228*	200×75×10,5 *235*	200×90×12,5 *260*	200×90×13 *270*	*273*
2,7		200×90×13 *267*	*275*	*296*	*309*	230×90×11 *320*	230×90×12 *341*	230×90×12,5 *351*
3,0		230×90×11 *321*	230×90×12 *341*	230×90×13 *354*	*380*	*393*	250×90×12 *423*	250×90×13 *445*
3,3		*392*	250×90×12 *424*	250×90×13 *444*	*477*	*495*	*507*	280×90×12 *541*
3,6		*476*	*505*	280×90×12 *543*	280×90×13 *567*	280×90×14 *592*	*612*	*648*
3,9		280×90×13 *565*	280×90×14 *592*	*624*	*655*	300×90×13,5 *672*	300×90×14 *687*	*726*
4,2		*655*	300×90×13,5 *671*	*706*	*735*	*749*	300×100×100×14 *798*	320×100×100×13,5 *875*
4,5	CHANNELS	*731*	*756*	300×100×100×14 *807*	300×100×100×15 *832*	320×100×100×13,5 *883*	320×100×100×15 *924*	350×100×100×14,5 *989*
4,8		300×100×100×15 *830*	320×100×100×13,5 *886*	320×100×100×15 *924*	350×100×100×14 *977*	350×100×100×15,5 *1019*	350×100×100×16 *1043*	
5,1		350×100×100×13 *940*	350×100×100×14,5 *996*	350×100×100×16 *1038*				
5,4		350×100×100×16,5 *1062*						
5,7								
6,0								
6,3								
6,6								
6,9								
7,2								
7,5								
7,8								
8,1								

For notes see page 161

TABLE 35

BULKHEAD STIFFENERS in TUGS

Spaced 610 mm. apart on collision bulkheads and 760 mm. apart on other watertight bulkheads

LENGTH OF STIFFENER	STIFFENERS BRACKETED AT ENDS	STIFFENERS WITHOUT BRACKETS OR LUGS AT ENDS
2,1		80×65× 8,5 *20,7*
2,4	75×65× 6,5 *14,5*	100×75× 7,5 *26,4*
2,7	75×65× 7,5 *16,0*	100×75× 8,5 *30,4*
3,0	80×65× 9 *21,8*	100×75×10,5 *37,3*
3,3	100×75× 8 *28,3*	120×75× 9 *45,2*
3,6	100×75×10 *34,7*	130×75× 9,5 *55,1*
3,9	120×75× 8,5 *42,7*	150×75× 9 *67,7*
4,2	130×75× 9,5 *54,2*	150×75×10,5 *79,0*
4,5	150×75× 9 *66,8*	150×75×12,5 *91,2*
4,8	150×75×10,5 *79*	

TABLE 36

END ATTACHMENTS for STIFFENERS

TYPE AND DEPTH OF STIFFENER		BRACKET ATTACHMENTS				LUG ATTACHMENTS	
		Thickness of bracket	Width of flange	Number and size of rivets in each arm of bracket	Area of weld	Number and size of rivets in lug	Area of weld
		mm.	mm.		sq. cm.		sq. cm.
Angles		8,5	—	3 of 19 mm. dia.	9,7	2 of 19 mm. dia.	6,5
Bulb Angles 150 mm. and under		9	—	3 ,, 19 ,, ,,	9,7	2 ,, 19 ,, ,,	6,5
Bulb Angles 180 mm.		10	—	4 ,, 19 ,, ,,	12,9	3 ,, 19 ,, ,,	9,7
,, ,, 200 ,,		10,5	—	5 ,, 19 ,, ,,	16,1	3 ,, 19 ,, ,,	9,7
,, ,, 230 ,,	FLANGED	8,5	60	6 ,, 19 ,, ,,	19,3	4 ,, 19 ,, ,,	12,9
,, ,, 250 ,,		9	65	7 ,, 19 ,, ,,	22,6	4 ,, 19 ,, ,,	12,9
,, ,, 280 ,,		9,5	70	7 ,, 22 ,, ,,	30,6	4 ,, 22 ,, ,,	17,7
,, ,, 300 ,,		10	75	8 ,, 22 ,, ,,	35,4	5 ,, 22 ,, ,,	22,6
Channels 300× 90× 90 mm.		10	75	9 ,, 22 ,, ,,	40,3	6 ,, 22 ,, ,,	25,8
Channels 300×100×100 mm.		10	75	10 ,, 22 ,, ,,	45,1	7 ,, 22 ,, ,,	30,6
Channels 380×100×100 mm.		11	90	13 ,, 22 ,, ,,	58,0	8 ,, 22 ,, ,,	35,4

NOTES.—TABLES 33, 34, 35 & 36

1. **Length of stiffeners** is to be measured over the full distance between the top and bottom boundaries of the bulkhead.

2. **Correction for spacing.**—If the spacing of the stiffeners differs from the Table spacing the modulus is to be modified in direct proportion.

3. **Welded construction.**—When the bulkhead plating, boundaries, stiffeners and end brackets are welded, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

4. **Area of weld** is the product of the throat thickness and the length of the weld. The throat thickness is not to be less than that required by Notes 5 and 6, Table 52 G.

5. Particulars of sections and moduli are given in Table 56.

TABLE 37

TUNNEL PLATING

Stiffeners spaced 915 mm. apart

DEPTH (*See* NOTE 1)	THICKNESS		DEPTH (*See* NOTE 1)	THICKNESS	
	FLAT SIDE PLATING	CURVED TOP PLATING		FLAT SIDE PLATING	CURVED TOP PLATING
Metres	Millimetres	Millimetres	Metres	Millimetres	Millimetres
2,5	7,5	6,5	**11**	11,5	10
3	7,5	7	**12**	12	10,5
4	8	7	**13**	12,5	11
5	8,5	7,5	**14**	12,5	11,5
6	9	8	**15**	13	12
7	9,5	8,5	**16**	14	12,5
8	10	9	**17**	14	12,5
9	10,5	9,5	**18**	14,5	13
10	11	9,5			

NOTES.—TABLE 37

1. **Depth** is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the lower edge of the plate.

2. **Correction for spacing of stiffeners.** When the spacing differs from 915 mm. the thickness is to be modified at the rate of 2 per cent for every 25 mm. of difference.

3. For additions under hatchways *see* D 1702 to D 1703.

For tunnels in deep tanks *see* D 1910 and D 2015.

TUNNEL STIFFENERS

Spaced 915 mm. apart

DEPTH (*See* NOTE 1)	LENGTH FROM BASE OF TUNNEL TO TOP OF FLAT SIDE					
	0,9	1,2	1,5	1,8	2,1	2,4
Metres	Millimetres *Modulus—centimetres³*					
3,6	75×65× 6 *12,5*	90×75× 8,0 *22,9*	100×75× 9,5 *33,1*	120×75× 9 *44,9*	130×75×10,0 *56,9*	140×65× 8 *88,1*
4,8	75×65× 7,0 *14,9*	90×75× 9,0 *26,2*	120×75× 8,5 *42,3*	130×75×10 *57,5*	140×65× 8 *87,7*	150×75× 8,5 *110*
6,0	90×65× 6,0 *17,9*	100×75× 9,5 *32,9*	130×75× 9,5 *54,6*	150×75× 9,5 *71,8*	150×75× 8,5 *108*	165×75× 8,5 *132*
7,2	90×75× 8,0 *23,9*	120×75× 8,5 *42,2*	140×75× 9,5 *61,7*	140×65× 8,5 *92,3*	150×75× 9,5 *117*	180×75× 8 *157*
8,4	90×75× 9,0 *25,9*	120×75× 9,5 *47,3*	150×75×10 *74,1*	150×75× 8,5 *109*	165×75× 9 *138*	180×75×10,5 *187*
9,6	100×75× 9 *32,4*	130×75× 9,5 *54,8*	140×65× 8,5 *91,9*	165×75× 8,5 *130*	180×75× 8,5 *164*	200×75× 9,5 *219*
10,8	100×75×10 *34,6*	140×75× 9,5 *61,3*	150×75× 8,5 *108*	165×75× 9,5 *140*	180×75×10,5 *186*	200×90×10,5 *234*
12,0	100×75×10,5 *36,5*	150×75× 9,5 *70,7*	150×75× 9 *113*	180×75× 8 *158*	200×75× 9,5 *218*	200×90×13 *269*
13,2	120×75× 8,5 *41,7*	150×75×10 *75,1*	165×75× 8 *129*	180×75×10,5 *186*	200×90×10,5 *235*	*300*
14,4	120×75× 9,5 *46,3*	140×65× 8,0 *87,8*	165×75× 9 *136*	180×75×11 *194*	200×90×12 *257*	*320*
15,6	120×75×11 *53,8*	140×65× 9 *94,2*	180×75× 8 *156*	200×75× 9,5 *219*	*296*	230×90×12,5 *351*
16,8	130×75×10 *56,9*	150×75× 8,5 *107*	180×75× 8,5 *165*	200×90×10,5 *233*	*317*	*384*
18,0	150×75× 8 *60,5*	150×75× 9 *113*	180×75×10,5 *185*	200×90×12 *256*	230×90×12 *342*	250×90×12 *427*

ANGLES — BULB ANGLES

NOTES.—TABLE 38

1. **Depth** is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the base of the tunnel.

2. **Correction for spacing.** If the spacing of the stiffeners differs from 915 mm. the Table modulus is to be modified in direct proportion.

3. Particulars of sections and moduli are given in Table 56.

LENGTH OF STIFFENER		NUMERAL					
		NOT EXCEEDING 15	30	45	60	85	110
		<— SINGLE STIFFENERS — >				<— DOUBLE STIFFENERS — >	
Metres		Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
2,4	ANGLES	100×75× 8,5	130×75× 9,0	150×75× 8,5	180×75× 9	150×75× 7,0	150×75× 9
3,0	ANGLES	130×75× 8,0	150×75× 8,0	165×75× 8,5	180×75×10	150×75× 7,5	150×75×10
3,6	ANGLES	130×75× 9,0	165×75× 8,0	180×75× 9	200×75×10	150×75× 8,5	165×75×10,5
4,2	ANGLES	130×75×10,0	165×75× 9,5	180×75×10,5	200×75×11,5	165×75× 8,5	180×75×10,5
4,8	BULB ANGLES	150×75× 9,0	180×75× 9,5	200×75×10,5	200×90×12,5	180×75× 9	200×75×10,5
5,4	BULB ANGLES	165×75× 9,0	200×75× 9,5	200×75×11,5	230×90×12	180×75×10	200×75×11,5
6,0	BULB ANGLES	180×75× 9,5	200×75×11	200×90×13	250×90×12,5	200×75×10	200×90×12
6,6	BULB ANGLES	180×75×11,0	200×90×12	230×90×12,5	280×90×14	200×75×11,5	230×90×12
7,2	BULB ANGLES	200×75×10,5	230×90×11	250×90×12,5	300×90×13,5	200×90×12	250×90×11,5
7,8	BULB ANGLES	200×90×11,0	250×90×11	280×90×12	300×90×13,5	230×90×11	250×90×13
8,4	BULB ANGLES	200×90×12,5	250×90×12	280×90×13	300×90×15	230×90×12	250×90×13,5
9,0	BULB ANGLES	230×90×12	250×90×13,5	280×90×14	200×90×11	250×90×11,5	280×90×13
9,6	BULB ANGLES	250×90×11	280×90×12	300×90×13,5	200×90×11,5	250×90×12,5	280×90×14

NOTES.—TABLE 39

1. **Length** of stiffener is to be measured between the top and bottom boundaries of the bulkhead.

2. **The numeral,** whether for stiffeners supporting deck beams, strong hatch end beams or deck transverses, is to be obtained as for pillars; *see* Table 31, notes 1 and 2.

3. **Arrangements with longitudinally framed decks.**—The stiffeners not supporting deck transverses are to have a modulus 25 per cent less than that derived from the column headed "Not exceeding 15". The ends of hold

NUMERAL					LENGTH OF STIFFENER
140	170	200	230	260	
<— DOUBLE STIFFENERS —>					
Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Metres
150×75×10,5	165×75×10	180×75×11	200×75×10,5	200×90×11,5	2,4
165×75×10	180×75×10,5	200×75×10,5	200×90×11	200×90×12,5	3,0
180×75×10,5	200×75×11	200×90×11	200×90×12,5	230×90×12,5	3,6
200×75×10,5	200×75×11,5	230×90×11,5	230×90×12,5	250×90×13,5	4,2
200×90×11	230×90×11	250×90×11,5	250×90×13	280×90×12,5	4,8
200×90×12,5	230×90×12,5	250×90×13	280×90×12	280×90×14	5,4
230×90×12	250×90×12,5	280×90×12,5	280×90×13,5	300×90×13,5	6,0
250×90×12,5	280×90×12	280×90×13,5	300×90×13,5	300×90×15	6,6
250×90×13,5	280×90×13	300×90×13,5	300×90×15		7,2
280×90×13	300×90×13	300×90×15			7,8
280×90×14	300×90×14,5				8,4
300×90×13,5					9,0
300×90×14,5					9,6

BULB ANGLES

NOTES.—TABLE 39 (*concluded*)

stiffeners are to be lugged or welded to the inner bottom and deck.

4. **Coal bunker bulkheads.** — The scantlings of stiffeners for bunker bulkheads, not supporting decks, are to be determined from the column headed "Not exceeding 15" for a spacing of 915 mm., but the modulus may be reduced by 25 per cent.

5. For end connections and constructional details *see* D 18.

TABLE 40 STIFFENERS ON BOUNDARY BULKHEADS OF DEEP TANKS,

Spaced 610 mm. apart

LENGTH OF STIFFENERS		HEAD H METRES							
		0,9	1,2	1,5	1,8	2,4	3,0	3,6	4,2
Metres		MILLIMETRES *Modulus—centimetres³*							
1,5	ANGLES	75×75× 6 *13,5*	75×75× 7,0 *15,5*	75×75× 8,5 *18,7*	75×75×10 *21,5*	90×75×10 *29,2*	100×75×10,5 *36,8*	*43,1*	*50,2*
1,8	ANGLES	75×75× 7,5 *15,9*	90×75× 7,5 *22,0*	100×75× 7,5 *26,7*	100×75× 9 *32,7*	*43,8*	120×75×11 *53,4*	150×75× 8,5 *64,1*	*73,2*
2,1	ANGLES	90×75× 7,5 *22,0*	100×75× 9 *32,2*	100×75×11 *39,7*	120×75× 9 *45,0*	130×75×10,5 *61,0*	140×75×11,5 *75,8*	*89,5*	150×75× 7,5 *102*
2,4	ANGLES	100×75× 8,5 *29,8*	120×75× 8 *40,0*	120×75×10 *49,8*	130×75×10 *57,8*	150×75×10,5 *78,2*	150×75× 7 *97,7*	150×75× 9,5 *116*	165×75× 8 *129*
2,7	ANGLES	100×75×10,5 *37,6*	*50,3*	140×75× 9,5 *62,2*	150×75×10 *74,5*	150×75× 7 *98,2*	150×75×10 *123*	165×75× 9,5 *145*	180×75× 9 *168*
3,0	ANGLES	*45,2*	150×75× 8 *60,6*	150×75×10,5 *78,0*	*91,3*	150×75×10 *124*	165×75×10,5 *152*	180×75×10 *181*	200×75× 9 *211*
3,3	ANGLES	*55,5*	*77,0*	150×75×12 *89,3*	150×75× 8,5 *110*	165×75×10 *148*	180×75×10 *182*	200×75× 9 *214*	200×75×11,5 *247*
3,6	ANGLES	150×75× 9,5 *70,9*	150×75×11,5 *85,5*	150×75× 8,5 *109*	165×75× 8 *128*	180×75× 9 *171*	200×75× 9 *211*	200×75×11,5 *249*	*289*
3,9	ANGLES	150×75×11 *80,7*	150×75× 7,0 *97*	150×75×10,5 *126*	165×75×10,5 *150*	*200*	200×75×11,5 *248*	*298*	230×90×11 *340*
4,2	ANGLES	150×75×11,5 *86,0*	150×75× 9 *114*	165×75× 9,5 *145*	180×75× 9,5 *176*	200×75×10,5 *237*	*293*	230×90×12 *346*	*397*
4,5	BULB ANGLES	150×75× 8 *104*	165×75× 9 *138*	180×75× 9,5 *173*	*203*	*276*	230×90×12 *343*	250×90×11 *399*	250×90×13,5 *458*
4,8	BULB ANGLES	150×75×10 *124*	180×75× 8,5 *162*	*203*	200×75×10,5 *236*	230×90×11 *322*	*394*	250×90×14 *460*	*519*
5,1	BULB ANGLES	165×75× 9,5 *143*	180×75×10,5 *189*	200×75×10,5 *235*	200×90×13 *268*	230×90×13 *358*	250×90×13 *450*	*527*	280×90×14,5 *598*
5,4	BULB ANGLES	180×75× 8,5 *163*	200×75× 9 *216*	200×90×13 *268*	*310*	250×90×11 *402*	*517*	280×90×14,5 *609*	300×90×14 *700*
5,7	BULB ANGLES	180×75×11 *190*	200×75×11,5 *250*	*309*	230×90×12,5 *353*	*472*	280×90×14 *595*	300×90×14 *703*	300×100×100×14 *800*
6,0	BULB ANGLES	*218*	*286*	230×90×12,5 *353*	250×90×11 *405*	280×90×12,5 *549*	300×90×13,5 *687*	300×100×100×14 *803*	320×100×100×14,5 *908*
6,3	BULB ANGLES	200×75×11 *245*	230×90×11 *325*	250×90×11 *403*	250×90×13,5 *458*	*633*	300×100×100×13,5 *787*	320×100×100×15 *924*	350×100×100×15,5 *1030*
6,6	BULB ANGLES	*277*	*368*	250×90×13,5 *457*	*535*	280×100×100×14 *720*	320×100×100×14 *893*	350×100×100×16 *1042*	380×100×100×15,5 *1183*
6,9	BULB ANGLES	230×90×11,0 *323*	250×90×11,5 *417*	*535*	*615*	300×100×100×14,5 *812*	350×100×100×15 *1002*	380×100×100×15,5 *1180*	400×110×110×14,5 *1338*
7,2	BULB ANGLES	*375*	250×90×14 *468*	280×90×14 *589*	300×90×14 *692*	320×100×100×14,5 *916*	380×100×100×14 *1118*	400×110×110×14,5 *1333*	*1528*

NOTES.—TABLE 40

1. **Length of stiffeners** on bulkheads is to be measured as follows:—

(*a*) Where horizontal girders are not fitted:

between the top and bottom boundaries.

(*b*) Where horizontal girders are fitted:

(i) between the top boundary and the highest girder,

(ii) between girder and girder,

(iii) between the lowest girder and the bottom boundary.

On tunnels passing through deep tanks and having a curved top, the length of stiffeners is to be measured from the base of the tunnel to the top of the flat side.

2. **Head H** is to be taken as the greater of the two following values:—

(*a*) the distance in metres from the mid-point of length as defined above to the top of the tank.

Spaced 610 mm. apart

HEAD H METRES 4,8	5,4	6,0	6,6	7,2	7,8	8,4		LENGTH OF STIFFENERS
MILLIMETRES *Modulus—centimetres³*								Metres
140×75× 8,5 *56,5*	150×75× 8,5 *63,3*	150×75× 9 *68,4*	150×75× 9,5 *72,0*	*80,0*	*90,0*	150×75× 8,5 *107*	BULB ANGLES	1,5
150×75×11 *82,1*	*91,5*	150×75× 7,5 *100*	150×75× 8,5 *109*	150×75× 9,5 *118*	165×75× 8 *128*	165×75× 9 *139*		1,8
150×75× 9 *114*	165×75× 8 *128*	165×75× 9,5 *141*	180×75× 8 *157*	180×75× 9 *168*	180×75×10 *178*	180×75×11,5 *189*		2,1
165×75×10,5 *153*	180×75× 9 *169*	180×75×10 *178*	*206*	200×75× 9,5 *221*	200×75×10,5 *235*	200×75×11,5 *249*		2,4
180×75×11 *191*	200×75× 9 *214*	200×75×10,5 *237*	200×75×12 *258*	*278*	*298*	*318*		2,7
200×75×10,5 *238*	200×90×12,5 *264*	*293*	230×90×11 *320*	230×90×12 *340*	230×90×13 *362*	*388*		3,0
277	*306*	230×90×12 *341*	230×90×13 *364*	*388*	250×90×12 *421*	250×90×13,5 *455*		3,3
230×90×11 *322*	230×90×13 *357*	*395*	250×90×12 *428*	250×90×14 *463*	*496*	*530*		3,6
383	250×90×12,5 *430*	250×90×14 *464*	*507*	280×90×12,5 *549*	280×90×14 *588*	*621*		3,9
250×90×13,5 *452*	*506*	280×90×12 *548*	280×90×14 *590*	*636*	300×90×13,5 *676*	300×90×14,5 *716*		4,2
518	280×90×13,5 *574*	*630*	300×90×13,5 *675*	280×100×100×14,5 *734*	300×100×100×13,5 *797*	300×100×100×15,5 *840*	CHANNELS	4,5
585	*647*	300×90×14,5 *710*	300×100×100×13 *782*	300×100×100×15,5 *843*	320×100×100×14,5 *904*	350×100×100×13,5 *966*		4,8
300×90×13 *670*	280×100×100×15 *744*	300×100×100×14,5 *819*	320×100×100×14 *897*	350×100×100×14 *970*				5,1
300×100×100×13 *778*	320×100×100×13 *869*	350×100×100×13,5 *959*						5,4
320×100×100×14,5 *905*	350×100×100×15 *1013*	380×100×100×14 *1113*						5,7
350×100×100×15,5 *1025*	380×100×100×14,5 *1146*	380×100×100×17,5 *1263*						6,0
380×100×100×16,5 *1170*	400×110×110×14 *1308*							6,3
400×110×110×14,5 *1347*	400×110×110×18 *1490*							6,6
1542								6,9
1740								7,2

NOTES.—TABLE 40 *(concluded)*

(*b*) half the distance in metres from the mid-point of length as defined above to the top of the overflow.

3. **Correction for spacing.** Where the spacing of the stiffeners differs from 610 mm., the modulus is to be modified in direct proportion.

4. **Welded construction.** When the bulkhead plating, boundaries, stiffeners and end brackets are welded and the stiffeners are not supported by horizontal girders, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

5. **Riveted end attachments** are to be in accordance with the requirements of Table 36.

6. Particulars of sections and moduli are given in Table 56.

TABLE 41 HORIZONTAL GIRDERS IN OIL FUEL BUNKERS

NUMERAL	GIRDER		NUMERAL	GIRDER	
	WEB PLATE	FACE AREA		WEB PLATE	FACE AREA
	Millimetres	Centimetres^2		Millimetres	Centimetres^2
50	330× 8,5	9,0	650	1100×11,5	53,5
100	430× 8,5	15,0	700	1160×11,5	55,0
150	520× 9,0	21,0	750	1210×11,5	55,5
200	600× 9,0	25,0	800	1220×11,5	60,0
250	670× 9,5	26,5	850	1230×11,5	67,5
300	740× 9,5	28,5	900	1240×11,5	72,5
350	790×10,0	31,5	950	1250×11,5	78,0
400	840×10,5	34,0	1000	1290×11,5	78,0
450	880×11,0	41,5	1100	1370×12,0	78,0
500	940×11,0	46,0	1200	1440×12,5	78,0
550	980×11,0	49,5	1300	1530×12,5	78,0
600	1040×11,5	51,0			

NOTES.—TABLE 41

1. **Numeral** = $s^2 \times b \times H$

where s = length, in metres, between centres of end brackets,

b = depth, in metres, between the centres of the two adjacent spans of stiffeners or frames supported by the girder,

H = for girders on bulkheads :—

the greater of the two following values :—

(*a*) the distance, in metres, from the girder to the top of the tank,

(*b*) half the distance, in metres, from the girder to the top of the overflow.

for girders supporting side frames :—

(*c*) the distance, in metres, from the girder to the upper deck at side. This distance need not, however, exceed 1,4d provided this is above the crown of the tank.

2. For tanks which exceed 9,15 metres in length the scantlings and arrangements will be specially considered.

3. The face area of girders derived from the Table may take the form of rolled sections, flanged girder plates or welded face plates, the width of the girder being the extreme width of the web plate.

4. For end connections and constructional details *see* D 2006 to D 2010.

A—RIVETED

BREADTH OF HATCHWAY	WEB PLATE — BEAM SPACING CENTRE TO CENTRE				DOUBLE ANGLES ON EDGES OF BEAMS
	Metres 1,25	Metres 1,50	Metres 1,75	Metres 2,00	
Metres	Millimetres *Modulus—centimetres³*				Millimetres
3	*240*	*310*	255× 7,5 *585*	285× 8 *705*	75×75×10
3,5	*385*	*420*	270× 8 *670*	330× 8,5 *869*	75×75×10
4	*475*	260× 8 *640*	320× 8,5 *860*	350× 9 *995*	75×75×10,5
4,5	245×8 *660*	310× 8 *910*	350× 9 *1100*	380× 9,5 *1245*	90×75×10,5
5	330×8 *980*	375× 8 *1165*	410× 9 *1360*	455× 9,5 *1525*	90×75×10,5
5,5	365×8,5 *1270*	405× 9 *1475*	450× 9 *1690*	485× 9,5 *1870*	100×75×11
6	390×8,5 *1380*	450× 9 *1680*	495× 9,5 *1915*	535× 9,5 *2130*	100×75×11
6,5	410×9 *1580*	475× 9 *1925*	530× 9,5 *2245*	570×10 *2505*	100×75×12
7	435×9 *1840*	500× 9,5 *2215*	560×10 *2615*	610×10,5 *2950*	120×90×11
7,5	455×9 *2125*	520× 9,5 *2540*	580×10 *2980*	635×10,5 *3385*	130×90×11,5
8	475×9 *2430*	540× 9,5 *2875*	605×10 *3350*	660×10,5 *3795*	140×90×12
8,5	495×9,5 *2770*	560× 9,5 *3240*	625×10 *3750*	685×10,5 *4275*	150×90×12,5
9	515×9,5 *3015*	575×10 *3510*	640×10,5 *4035*	700×11 *4580*	150×90×13

B—RIVETED

3	*181*	*234*	*262*	*293*	75×75×10
3,5	*236*	*301*	*347*	*422*	75×75×10
4	*301*	*375*	225× 7,5 *525*	260× 8 *640*	75×75×10,5
4,5	*505*	*555*	265× 8 *725*	295× 8 *850*	90×75×10,5
5	285×7,5 *805*	290× 7,5 *825*	310× 8 *900*	340× 8,5 *1040*	90×75×10,5
5,5	290×7,5 *900*	310× 8 *1000*	345× 8,5 *1180*	380× 9 *1350*	100×75×11
6	310×8 *995*	330× 8,5 *1100*	385× 9 *1360*	425× 9 *1560*	100×75×11
6,5	320×8 *1125*	350× 8,5 *1265*	410× 9 *1575*	455× 9 *1810*	100×75×12
7	335×8,5 *1285*	365× 8,5 *1450*	430× 9 *1810*	475× 9,5 *2075*	120×90×11
7,5	345×8,5 *1460*	375× 8,5 *1645*	450× 9 *2075*	490× 9,5 *2375*	130×90×11,5
8	355×8,5 *1645*	390× 8,5 *1855*	470× 9 *2390*	515× 9,5 *2720*	140×90×12
8,5	365×8,5 *1855*	405× 9 *2125*	485× 9,5 *2715*	535× 9,5 *3065*	150×90×12,5
9	385×8,5 *2050*	425× 9 *2355*	505× 9,5 *2950*	555× 9,5 *3310*	150×90×13

For notes see page 170

TABLE 43 C HATCHWAY BEAMS

C—WELDED

DEPTH OF BEAM OVER FACE PLATES	BASIC WEB THICKNESS	* CORRECTION TO MODULUS PER 1 MM. VARIATION IN WEB THICKNESS	BASIC FLANGE THICKNESS	† CORRECTION TO MODULUS PER 1 MM. VARIATION IN FLANGE THICKNESS	AREA OF EACH FACE PLATE SQUARE CENTIMETRES											
					20	25	30	35	40	45	50	55	60	65	70	75
					MODULUS											
Millimetres	Millimetres	Centimetres³	Millimetres	Centimetres³	← Centimetres³ →											
200	9	*4*	15	*7*	*379*	*465*	*551*	*636*								
250	9	*7*	15,5	*7*	*503*	*613*	*722*	*832*								
300	10	*10*	17,5	*8*		*770*	*902*	*1035*	*1168*							
350	10	*15*	18	*9*		*936*	*1093*	*1250*	*1408*	*1564*						
400	11,5	*20*	20	*11*			*1307*	*1488*	*1668*	*1848*	*2028*					
450	11,5	*25*	20,5	*13*			*1522*	*1727*	*1931*	*2136*	*2340*	*2547*	*2751*			
500	12,5	*31*	22,5	*14*					*2214*	*2442*	*2671*	*2898*	*3127*	*3356*		
550	12,5	*38*	23	*15*					*2505*	*2758*	*3009*	*3263*	*3517*	*3770*	*4019*	
600	14	*46*	25	*17*						*3128*	*3403*	*3678*	*3954*	*4229*	*4507*	*4781*

* When the thickness of the web is increased, the modulus is to be increased by the appropriate correction
† When the thickness of the flange is increased, the modulus is to be reduced by the appropriate correction

NOTES.—TABLE 43

1. **Scantlings** of riveted hatchway beams are to be determined from the Table as follows :—

For hatchways requiring coamings 610 mm. in height (D 2301 to D 2302), in ships 61 metres or more in length ... ... A
in ships 30,5 metres or less in length ... ... B
(For intermediate lengths scantlings are to be determined by interpolation.)

For hatchways requiring coamings 457 mm. in height, or less, except in cargo spaces ... B
For hatchways in cargo spaces (*see also* note 4) ... A
For hatchways in accommodation spaces ... ... B

2. The Table depth of hatchway beams is to be measured at the mid-length from the top of the upper mounting angles to the bottom of the lower mounting angles or bulb plate. The depth of the ends may be half that at the centre but is not to be less than 150 mm. Alternative arrangements may be adopted if suitable strength is provided at the ends of the webs. The larger flange of the mountings is to be fitted horizontally.

3. Scantlings of welded hatchway beams may be obtained from C on the basis of modulus equivalent to the requirements of A or B. The width of the face plates is to be sufficient to provide the minimum hatch bearing surface required by D 2313.

4. Where the 'tween deck height in cargo spaces and trunked hatchways (*see* D 2330) exceeds 2,6 metres the modulus of the hatchway beams is to be increased in direct proportion.

5. For construction details *see* D 2310 to D 2316.
For riveting and welding *see* Table 52 H.

6. Where built steel hatchway covers are fitted, the scantlings are to be in accordance with the following formulæ :

	Type A (Note 1)	Type B (Note 1)
Section Modulus of stiffeners (including plating) in cm.³	$23\ SL^2$	$17\ SL^2$
Moment of inertia of stiffeners (including plating) in cm.⁴	$39\ SL^3$	$29\ SL^3$

Where L = unsupported span of stiffeners, in metres.
S = spacing of stiffeners, in metres.

Thickness of plating in mm. $6{,}5+\frac{S-610}{150}$ $6+\frac{S-610}{200}$

Where S = spacing of stiffeners, in mm.
For pontoon hatch covers, *see* D 2326.

7. Where deck cargoes are to be carried on upper deck hatches the scantlings of Type A and B hatches will require to be increased if the equivalent height (at 1,39 cubic metres per 1000 kg.) exceeds 2,6 metres and 1,98 metres respectively. (*See also* D 1113).

DIAMETER OF RUDDER HEADS

TABLE 44

NUMERAL	SEA SPEED IN KNOTS						
	10 and below	12	14	16	18	20	22
	DIAMETER OF RUDDER HEAD (Millimetres)						
85	90	95	100	110			
110	100	105	115	120			
140	110	115	120	135			
170	115	120	130	140			
200	120	130	135	145			
230	130	135	140	155			
260	135	140	150	160	175		
290	140	150	160	175	190		
340	150	160	170	185	195		
400	160	165	180	190	205	215	
455	170	180	190	205	215	230	
540	185	190	205	215	230	240	
620	195	205	215	230	240	255	275
735	210	215	230	240	255	265	285
850	215	225	235	250	265	280	300
990	230	235	250	260	280	290	310
1130	240	240	260	275	290	305	330
1280	255	255	265	280	305	320	345
1450	265	265	280	290	315	330	355
1615	280	280	290	305	330	345	375
1815	290	290	305	320	345	365	395
2040	305	305	320	330	355	380	405
2265	320	320	330	345	370	395	420
2520	330	330	345	355	380	405	435
2775	345	345	355	370	395	420	450
3060	355	355	370	390	415	440	465
3340	370	370	380	405	430	460	485
3655	380	380	395	420	445	470	495
3965	395	395	405	430	455	480	510

NOTES.—TABLE 44

1. **Numeral.**—(*a*) The numeral $= 100 \times A \times D$ where :

A = total area of rudder in square metres, including balanced portion, if any.

D = distance in metres of centre of gravity of area A from the centre line of the pintles.

(*b*) For balanced rudders the numeral is not to be less than 80 per cent of that derived from the part of the rudder abaft the centre line of the pintles.

2. For rudders strengthened for navigation in ice *see* D 1011, D 1023, D 1030 and D 1037.

3. Where steel complying with P 614, third sub-paragraph, or scrap material (*see* D 2603) is used the diameter of rudder head is to be increased by 5 per cent.

TABLE 45

SINGLE PLATE RUDDERS

DIAMETER OF RUDDER HEAD TABLE 44	ARMS—SPACED 1220 mm. BETWEEN CENTRES				PLATE	DIAMETER OF RIVETS SPACED 4½ DIAMETERS APART CENTRE TO CENTRE
	BREADTH	THICKNESS				
		AT MAINPIECE	ROUND MAINPIECE	AT ENDS		
Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
75	75	50	35	19	20	22
100	100	60	45	22	20,5	25
125	125	70	54	25	21	28
150	140	80	57	25	21,5	28
175	150	90	64	25	22	28
205	165	100	70	25	22,5	32
230	175	110	76	25	23	32
255	190	115	83	28	23,5	32
280	205	125	89	28	24	32
305	215	135	92	28	24,5	32
330	220	145	95	28	24,5	32
355	230	150	98	28	25	32
380	235	160	102	28	25	32

NOTES.—TABLE 45

Corrections for spacing of arms.—The breadth of the arms is to be modified directly as the spacing.

The thickness of the plate is to be modified with the spacing at the rate of 1 mm. for every 100 mm. increase or reduction from 1220 mm.

DOUBLE PLATE RUDDERS

TABLE 46

SIDE PLATES

DIAMETER OF RUDDER HEAD TABLE 44	SPACING OF ARMS BETWEEN CENTRES MILLIMETRES			SOLID FRAMES
	FORGED & CAST FRAMES			DIAMETER OF RIVETS SPACED 4½ DIAMETERS APART CENTRE TO CENTRE
	915	1220	1525	
	PLATE FRAMES			
	610	915	1220	
Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
100	9,0	11,5		19
125	9,5	12,0		19
150	9,5	12,5		22
175	10,0	12,5	15,0	22
205	10,5	13,0	15,5	22
230	11,0	13,5	16,0	22
255	11,0	13,5	16,5	25
280	11,5	14,0	16,5	25
305	12,0	14,5	17,0	25
330	12,0	14,5	17,5	25
355	12,5	15,0	18,0	25
380	13,0	15,5	18,5	25

NOTES.—TABLE 46

1. **Plate thickness.**—When the ratio of the fore and aft dimension to the vertical dimension of the unsupported panels of plating exceeds 3 : 2 an additional vertical diaphragm is to be fitted.

The thickness of side plates of rudder with a plate frame may require to be increased in way of the vertical webs which replace the mainpiece.

The thickness of the nose plate is not to be less than that required for the side plates at a 1220 millimetres spacing of plate frames.

2. **Plate frames.**—Horizontal webs and vertical webs not replacing the mainpiece are to have the same thickness as the side plates, but the plates forming the top and bottom of the rudder are to be of increased thickness.

Vertical webs replacing the mainpiece are to have a thickness equal to twice the Table thickness of side plates for 760 mm. spacing.

TABLE 47

RUDDER PINTLES

ONE OR TWO PINTLES
BALANCED OR UNBALANCED RUDDERS

AREA SUPPORTED (*See* NOTE 1)	SEA SPEED IN KNOTS					
	12 and below	14	16	18	20	22
	DIAMETER OF PINTLES					
Metres^2	< Millimetres >					
1	80	90	100			
2	115	125	140			
4	155	160	170	195	215	
6	195	195	205	225	250	280
8	205	205	215	240	270	305
10		225	235	255	290	335
12		240	250	280	315	365
14		260	270	300	335	390
16			290	325	365	420
18			315	345	395	450

THREE OR MORE PINTLES
UNBALANCED RUDDERS

AREA SUPPORTED (*See* NOTE 1)	SEA SPEED IN KNOTS				
	12 and below	14	16	18	20
	DIAMETER OF PINTLES				
Metres^2	< Millimetres >				
1	65	75	85		
2	105	115	125		
3	130	140	150	175	
4	160	165	175	190	
5	180	180	190	210	235
6	195	195	205	225	250

NOTES.—TABLE 47

1. **Area supported.**—When there is one pintle only the area supported is that below a horizontal line half way between the pintle and the top of the rudder.

Where there are two pintles the areas supported are those bounded by a horizontal line midway between the two pintles.

Where there are more than two pintles the area supported is to be taken as the total area of the rudder divided by the number of pintles.

2. **Pintles.**—The diameter of pintles obtained from the Table is to be measured outside the liner, if fitted.

The bearing length is to be 20 per cent greater than the diameter, except that where three or more pintles are fitted, the bearing length of the bottom pintle need only be equal to the diameter.

The length of pintle housing in the rudder gudgeons is to be 20 per cent greater than the diameter of the pintle.

Pintles are to be fitted as taper bolts, the taper not being greater than 1 in 12 on the radius.

DIAMETER OF RUDDER HEAD TABLE 44	HORIZONTAL COUPLING		VERTICAL COUPLING		SCARPHED COUPLING					
	6 BOLTS		8 BOLTS			WIDTH OF SCARPHS		BOLTS		
	MEAN DISTANCE OF CENTRES OF BOLTS FROM CENTRE OF COUPLING	DIAMETER OF BOLTS AND THICKNESS OF FLANGES	WIDTH OF COUPLING	DIAMETER OF BOLTS AND THICKNESS OF FLANGES	LENGTH OF SCARPH	AT TOP	AT BOTTOM	NUMBER		DIAMETER
								TOTAL	IN TOP ROW	
Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres			Millimetres
90	100	28								
95	105	28								
100	110	32								
110	110	32								
115	115	35	305	35	345	230	380	6	2	38
120	115	35	305	35	345	230	380	6	2	38
125	115	35	305	35	345	230	380	6	2	38
135	120	38	305	38	345	230	380	6	2	38
140	125	38	320	38	355	240	395	6	2	41
145	135	38	330	38	370	255	410	6	2	44
150	140	41	345	41	385	265	425	6	2	48
160	145	44	355	44	400	280	440	6	2	51
165	150	48	370	48	415	290	455	6	2	54
170	160	48	385	48	430	300	475	6	2	54
180	165	51	400	51	445	310	495	6	2	57
185	170	54	415	54	460	325	515	6	2	57
190	180	54	425	54	475	335	535	7	2	54
195	185	57	440	57	495	345	545	7	2	54
205	190	60	455	60	510	355	560	7	2	57
215	195	63	480	63	540	380	610	7	2	63
230	205	70	510	70	570	400	635	7	2	67
240	215	73	540	73	605	425	665	7	2	70
255	230	76	570	76	635	445	700	7	2	73
265	240	79	600	79	665	470	735	8	2	73
280	255	83	630	83	700	490	765	8	2	76
290	265	86	660	86	730	515	800	8	2	79
305	275	89	685	89	760	535	840	8	2	83
320	285	92	710	92	795	635	875	9	3	83
330	300	95	735	95	825	660	915	9	3	83
345	310	98	765	98	855	685	950	9	3	86
355	320	102	795	102	890	710	985	9	3	92
370	330	105	825	105	920	735	1015	9	3	95
380	345	108	850	108	950	760	1040	9	3	98

NOTES.—TABLE 48

1. The width of material in the flanges, or palms of scarphs, outside the bolt holes is not to be less than two thirds of the diameter of the bolt.

2. In scarphed couplings the athwartship dimension at the top of the scarph is not to be less than the diameter of the rudder head. The thickness of the tips of the palms is not to be less than 13 per cent of the diameter of the rudder head.

TABLE 49 STEERING CHAINS, RODS, QUADRANTS AND TILLERS

DIAMETER OF RUDDER HEAD TABLE 44	DIAMETER OF WROUGHT IRON CHAINS	DIAMETER OF RODS	RADIUS OF QUADRANT	BOSS OF QUADRANT		QUADRANTS AND TILLERS		
				Depth	Outside diameter	Size of arms at twice the diameter of rudder head from centre of rudder head		
						One arm	Two arms	Three arms
Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
90	14,5	16	965	90	160	90× 65		
95	14,5	16	990	95	170	100× 65		
100	16	17,5	1015	100	185	110× 65		
110	17,5	19	1040	110	190	115× 70		
115	17,5	19	1065	115	205	125× 70	95× 55	
120	19	20,5	1090	120	215	135× 70	100× 55	
125	19	20,5	1115	125	230	140× 75	110× 65	
135	20,5	22	1145	135	235	145× 75	115× 65	
140	20,5	24	1170	140	250	150× 85	120× 65	
145	22	24	1195	145	260	160× 85	125× 65	
150	22	25,5	1220	150	275	165× 90	135× 70	
160	24	27	1245	160	285	170× 90	140× 70	
165	24	27	1270	165	300	180× 95	140× 75	
170	25,5	29	1295	170	305	185× 95	145× 75	
180	25,5	32	1320	180	320	190×100	150× 85	
185	27	32	1345	185	330	195×110	150× 85	
190	27	33,5	1370	190	345	205×115	160× 90	
195	29	35	1395	195	355	210×115	160× 95	
205	30,5	35	1420	205	370	215×120	165×100	145× 90
215	32	38	1525	215	385	230×125	180×100	150× 95
230	33,5	40	1625	230	410	240×135	190×110	165× 95
240	35	42,5	1725	240	430	255×145	205×115	180×100
255	36,5	44,5	1830	255	445	265×150	215×115	190×100
265	38	47,5	1930	265	480	280×160	230×120	205×100
280	40	49	2030	280	500	290×170	240×125	210×115
290	41,5	49	2135	290	525	305×180	255×135	215×125
305	41,5	51	2235	305	545	320×190	265×140	230×125
320			2340	320	570	330×190	280×140	240×125
330			2440	330	595	345×190	285×145	255×125
345			2440	345	620	355×205	290×150	255×135
355			2440	355	640	370×205	305×150	265×135
370			2440	370	665	380×215	310×165	265×140
380			2440	380	685	395×215	325×165	280×140

NOTE.—TABLE 49

Where special steel short link chains (*see* P 1301 Grade U2) are used, the diameter given in column 2 above may be reduced as follows :—

Table size	*Reduction*
mm.	*mm.*
25 and below	1,5
25,5 — 30,5	3
31 — 41	4,5

BOLTS FOR BOLTED TILLERS AND QUADRANTS — TABLE 50

DIAMETER OF RUDDER HEAD TABLE 44	ONE BOLT EACH SIDE		TWO BOLTS EACH SIDE		FOUR BOLTS EACH SIDE			THICKNESS OF COUPLING
	Diameter	Distance centre to centre	Diameter	Distance centre to centre	Diameter	Inner bolts centre to centre	Outer bolts centre to centre	
Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
90	38	280	32	254	19	215	345	35
100	44	305	35	280	22	240	380	38
115	51	330	38	305	25	265	420	41
125	57	355	44	330	29	290	455	44
140	63	380	48	355	32	320	510	47
150	70	420	51	380	35	345	560	50
165	76	455	54	405	38	380	610	50
180	83	480	57	430	41	405	650	55
190	89	520	63	470	44	430	700	55
205	95	560	67	510	48	470	750	65
215	98	585	70	535	51	495	800	65
230	102	610	73	560	54	520	850	70
240			76	595	54	545	875	70
255			83	620	57	570	915	75
265			86	660	60	610	965	75
280			92	685	63	635	1015	75
290			95	725	67	660	1065	75
305			98	750	70	685	1105	85
330			108	815	76	750	1205	85
355			115	875	79	815	1295	85
380			123	940	86	865	1370	85

TABLE 51A

MAST SCANTLINGS AND FACTOR "B"

Mast Length		Total Resultant of Horizontal Pulls of Span Tackles						
		No Load	5 tonnes	10 tonnes	15 tonnes	20 tonnes	25 tonnes	30 tonnes
metres		mm.	mm.	mm.	mm.	mm.	mm.	mm.
9,25	Mast size	300×6	460×7,5	510×9	570×12	630×12,5	700×12,5	760×12,5
	Factor B	0,030	0,112	0,265	0,439	0,680	0,939	1,246
10,75	Mast size	360×6,5	510×8	570×10	630×11,5	700×12	760×12	810×13
	Factor B	0,030	0,101	0,243	0,430	0,639	0,885	1,137
12,25	Mast size	410×7	560×7,5	620×10,5	670×12	740×12,5	790×13,5	840×14
	Factor B	0,030	0,093	0,230	0,394	0,591	0,799	1,018
13,75	Mast size	460×7,5	580×8	650×10,5	710×12	760×13	810×14	860×14,5
	Factor B	0,030	0,082	0,217	0,368	0,538	0,730	0,927
15,25	Mast size	510×8	610×9,5	690×11	740×13	790×14	840×14,5	900×15,5
	Factor B	0,030	0,072	0,202	0,338	0,497	0,674	0,854
16,75	Mast size	560×8,5	660×9,5	720×11	790×12,5	840×14	890×14,5	940×15,5
	Factor B	0,030	0,068	0,190	0,328	0,478	0,648	0,824
18,25	Mast size	610×9	710×10	760×11	810×13,5	860×15	910×15,5	970×16
	Factor B	0,030	0,059	0,180	0,304	0,443	0,600	0,774

TABLE 51B

STAY EFFICIENCY FACTOR "C"

x/h	h/v						
	0,6	0,7	0,8	0,9	1,0	1,2	1,5
0,0	0,227	0,269	0,308	0,333	0,353	0,377	0,384
0,1	0,225	0,267	0,304	0,330	0,350	0,372	0,380
0,2	0,217	0,258	0,294	0,318	0,338	0,361	0,367
0,3	0,206	0,243	0,278	0,301	0,320	0,341	0,347
0,4	0,189	0,225	0,257	0,278	0,296	0,315	0,321
0,5	0,171	0,202	0,231	0,250	0,265	0,283	0,288
0,6	0,145	0,172	0,196	0,212	0,225	0,241	0,245
0,7	0,117	0,139	0,159	0,172	0,183	0,195	0,198
0,8	0,082	0,097	0,111	0,120	0,128	0,136	0,139
0,9	0,044	0,052	0,059	0,064	0,068	0,071	0,073
1,0	0	0	0	0	0	0	0

TABLE 51C

WIRE ROPE DIAMETERS FOR VARYING VALUES OF A_W

Diameter (mm.)	Construction			
	6×7	6×19	7×7	7×19
	A_W	A_W	A_W	A_W
8	0,037	0,037	—	—
9	0,045	0,050	—	—
10	0,057	0,059	0,067	—
11	0,069	0,069	0,081	—
12	0,088	0,089	0,104	—
14	0,116	0,114	0,137	0,135
16	0,150	0,154	0,176	0,184
18	0,187	0,185	0,220	0,220
20	0,240	0,236	0,283	0,282
22	0,286	0,275	0,338	0,326
24	0,338	0,336	0,396	0,386
26	0,393	0,402	0,462	0,481
28	0,466	0,452	0,550	0,541
32	0,598	0,587	0,703	0,701
36	0,769	0,738	0,903	0,881
40	0,936	0,943	—	1,127
44	—	1,136	—	1,352
48	—	1,361	—	1,604
52	—	1,569	—	1,872
56	—	1,812	—	2,160

TABLE 52 A

RIVETING AND WELDING

A

DIAMETER AND SPACING OF RIVETS AND BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS

THICKNESS OF PLATES:—	Millimetres Not exceeding 9	Millimetres Above 9 and not exceeding 12,5	Millimetres Above 12,5 and not exceeding 18,5	Millimetres Above 18,5 and not exceeding 24	Millimetres Above 24 and not exceeding 29	Millimetres Above 29 and not exceeding 32
DIAMETER OF RIVETS:—	16	19	22	25	28	31
SPACING IN DIAMETERS	SPACING IN MILLIMETRES					
$3\frac{1}{2}$	55	65	80	90	100	110
4	65	75	90	100	115	125
$4\frac{1}{2}$	70	85	100	115	125	140
5	80	95	110	125	145	155
$5\frac{1}{2}$	90	105	125	140	155	—
6	95	115	135	150	170	—
$6\frac{1}{2}$	100	125	145	165	—	—
7	115	135	160	180	—	—

BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS

		Millimetres	Millimetres	Millimetres	Millimetres	Millimetres	Millimetres
END LAPS	Single Riveted ...	65	75	—	—	—	—
	Double Riveted ...	110	125	150	—	—	—
	Treble Riveted ...	150	190	230	265	305	310
	Quadruple Riveted ...	—	—	305	355	405	420
	Quintuple Riveted ...	—	—	380	445	510	530
BUTT STRAPS*	Single Riveted ...	115	135	—	—	—	—
	Double Riveted ...	205	250	285	—	—	—
	Treble Riveted ...	—	360	425	485	545	560
	Quadruple Riveted ...	—	—	560	635	720	745
SEAMS	Single Riveted ...	55	65	75	90	—	—
	Double Riveted ...	95	115	135	150	170	175
	Treble Riveted ...	—	—	—	215	240	250

* Single butt straps are to be 25 per cent thicker than the plates to be connected. Where double butt straps are fitted the thickness of the countersunk strap is to be 70 per cent and the thickness of the strap on the opposite side is to be 60 per cent of the thickness of the plates to be connected.

NOTES.—TABLE 52 A

1. The diameter of rivets in seams of keel, sheerstrake, deck stringer, middle line strake of inner bottom and margin plate is to be regulated by the thickness of the adjacent plating.

2. Rivets are to be kept sufficiently clear of edges of plating and of each other, and the distance from the centre of rivet holes to the edges of the plating, end laps or butt straps is not to be less than one and a half rivet diameters.

3. The distance between the centres of consecutive rows of rivets is to be three and a half diameters in end laps, three diameters in butt straps and two and a half diameters in seams.

TABLE 52 B

END LAPS AND SEAMS OF SHELL PLATING

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth		Spacing of rivets centre to centre	Type of seam	Breadth
					End laps	Butt strap			
	Millimetres	Millimetres	Millimetres		Millimetres	Millimetres	Millimetres		Millimetres
Sheerstrake for 0,4L amidships. *See* note 4. Bottom Plating from keel to upper turn of bilge for 0,4L amidships. Keel Plates. *See* note 4. Boss Plates.		9	16	Double	110	205	55	Single	55
	9	10,5	19	Double	125	250	75	Double	115
	10,5	12,5	19	Treble	190	360	75	Double	115
	12,5	17,5	22	Treble	230	425	90	Double	135
	17,5	18,5	22	Quadruple	305	560	90	Double	135
	18,5	21,5	25	Quadruple	355	635	100	Double	150
	21,5	24	25	Quintuple	445		115	Double	150
	24	29	28	Quintuple	510		125	Double	170
	29	32	31	Quintuple	530		140		
Sheerstrake at ends. Bottom Plating from keel to upper turn of bilge at ends.		9	16	Double	110	205	55	Single	55
	9	10,5	19	Double	125	250	75	Double	115
	10,5	12,5	19	Treble	190	360	75	Double	115
	12,5	17,5	22	Treble	230	425	90	Double	135
	17,5	18,5	22	Quadruple	305	560	90	Double	135
	18,5	24	25	Quadruple	355	635	100	Double	150
Side Plating from upper turn of bilge to sheerstrake.		9	16	Double	110	205	55	Single	55
	9	10,5	19	Double	125	250	75	Single	65
	10,5	12,5	19	Treble	190	360	75	Double	115
	12,5	17,5	22	Treble	230	425	90	Double	135
	17,5	18,5	22	Quadruple	305	560	90	Double	135
	18,5	21,5	25	Quadruple	355	635	100	Double	150
	21,5	24	25	Quadruple	355	635	100	Treble	215
	24	26,5	28	Quadruple	405	720	115	Treble	240

NOTES.—TABLE 52 B

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. The number of rows of rivets in seams all fore and aft is to be regulated by the thickness of plating amidships. (Except as covered by notes 7 and 8.)

3. Seams of side plating in all ships exceeding 84 metres in length are to be not less than double riveted. (Except as covered by note 8.)

4. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the adjacent plating. (Except as covered by note 8.)

5. For number of rivets between frames in seams of shell plating *see* Table 52 E. Where the form of the ship, forward and aft, is curved the spacing of the rivets is not to exceed $4\frac{1}{2}$ diameters. (For special requirements for ships above 152,5 metres *see* note 7.) Where longitudinal framing is adopted the spacing of rivets in seams of shell plating is not to exceed $4\frac{1}{2}$ diameters, or 4 diameters in way of the strengthening of bottom forward.

6. For riveting in way of strengthening of bottom forward *see* D 808. For riveting in oil fuel bunkers *see* Table 52 H.

7. In ships above 152,5 metres in length in the three seams nearest to the neutral axis and for one-fourth of the ship's length in the forward and after bodies the following additions are to be made :—

Above 152,5 metres and not exceeding 160 metres an additional pair of rivets is to be fitted in each frame space.
Above 160 metres and not exceeding 167,5 metres two additional pairs of rivets are to be fitted in each frame space.
Above 167,5 metres and not exceeding 183 metres one seam, and in ships exceeding 183 metres two seams, are to be treble riveted, two additional pairs of rivets being fitted in each frame space in the other seam or seams.
In all the above ships one additional pair of rivets only need be fitted in way of 685 mm. frame spacing.

8. In ships where the draught does not exceed 0,7D (D being measured to the uppermost continuous deck) and the riveting required by Table 19 for the strength deck stringer angle is single, the lower edge of the sheerstrake may also be single riveted.

9. Seams of long bridges may be single riveted where the riveting required by Table 19 is single but are to be double riveted for four frame spaces at the ends.

10. Seams of poops, short bridges and forecastles may be single riveted.

11. In single riveted seams the rivet is to pass through the frame. In double riveted seams one frame rivet (that adjacent to the caulking edge) is to pass through the seams at each frame except where the frames or edges of the plating are joggled when both rivets are to pass through the frame. In treble riveted seams two frame rivets, the upper and the lower, are to pass through the seams at each frame.

TABLE 52 C

RIVETING AND WELDING

C

END LAPS AND SEAMS OF DECK PLATING

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth		Spacing of rivets centre to centre	Type of seam	Breadth
					End laps	Butt strap			
	Millimetres	Millimetres	Millimetres		Millimetres	Millimetres	Millimetres		Millimetres
Strength deck stringer plates for 0,4L amidships.		9	16	Double	110	205	65		
	9	10,5	19	Double	125	250	75		
	10,5	12,5	19	Treble	190	360	75	*See*	
	12,5	17,5	22	Treble	230	425	90		
	17,5	18,5	22	Quadruple	305	560	90	Note	
	18,5	21,5	25	Quadruple	355	635	100		
	21,5	24	25	Quintuple	445		115	2	
	24	29	28	Quintuple	510		125		
	29	32	31	Quintuple	530		140		
Strength deck stringer plates at ends. Lower deck stringer plates. Deck tie plates.		9	16	Double	110	205	70		
	9	10,5	19	Double	125	250	85		
	10,5	12,5	19	Treble	190	360	85	*See*	
	12,5	17,5	22	Treble	230	425	100		
	17,5	18,5	22	Quadruple	305	560	100	Note	
	18,5	24	25	Quadruple	355	635	115		
	24	29	28	Quadruple	405	720	125	2	
	29	32	31	Quadruple	420	745	140		
Strength deck plating for 0,4L amidships.		9	16	Double	110	205	65	Single	55
	9	12	19	Double	125	250	75	Single	65
	12	12,5	19	Treble	190	360	75	Single	65
	12,5	17,5	22	Treble	230	425	90	Single	75
	17,5	18,5	22	Quadruple	305	560	90	Single	75
	18,5	19,5	25	Quadruple	355	635	100	Single	90
	19,5	24	25	Quadruple	355	635	100	Double	150
	24	29	28	Quadruple	405	720	115	Double	170
Lower deck plating for 0,4L amidships.		9	16	Double	110	205	70	Single	55
	9	12	19	Double	125	250	85	Single	65
	12	12,5	19	Treble	190	360	85	Single	65
	12,5	17,5	22	Treble	230	425	100	Single	75
Deck plating at ends.		9	16	Single	65	115	70	Single	55
	9	10,5	19	Single	75	135	85	Single	65
	10,5	12,5	19	Double	125	250	85	Single	65
	12,5	13,5	22	Double	150	285	100	Single	75
	13,5	17,5	22	Treble	230	425	100	Single	75

NOTES.—TABLE 52 C

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. In seams of stringer plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent deck plating.

3. For number of rivets between beams in seams of deck plating *see* Table 52 E. The spacing of rivets in seams not parallel with the middle line of the ship, and in seams over deep tanks and oil cargo tanks, is not to exceed $4\frac{1}{2}$ diameters. Where longitudinal framing is adopted the spacing of rivets in seams of deck plating is not to exceed $4\frac{1}{2}$ diameters.

4. Where the riveting is not otherwise required to be increased the seams and butts of deck plating over oil fuel bunkers may be single riveted if not more than 8,5 metres below the top of the overflow ; elsewhere the riveting is to be double.

5. For riveting of stringer angles on strength decks *see* Table 19. For riveting of stringer angles on lower decks *see* Table 52 F.

6. Butts of deck plating within line of openings need only be single riveted.

RIVETING AND WELDING

D

END LAPS AND SEAMS OF DOUBLE BOTTOMS

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth		Spacing of rivets centre to centre	Type of seam	Breadth
					End laps	Butt strap			
	Millimetres	Millimetres	Millimetres		Millimetres	Millimetres	Millimetres		Millimetres
Inner bottom middle line strake. Inner bottom plating for 0,4L amidships. Margin plates. Centre and side girders (butts).		9	16	Double	110	205	65	Single	55
	9	12	19	Double	125	250	75	Single	65
	12	12,5	19	Treble	190	360	75	Double	115
	12,5	17,5	22	Treble	230	425	90	Double	135
	17,5	18,5	22	Quadruple	305	560	90	Double	135
	18,5	24	25	Quadruple	355	635	100		
Inner bottom plating at ends.		9	16	Single	65	115	65	Single	55
	9	10,5	19	Single	75	135	75	Single	65
	10,5	12	19	Double	125	250	75	Single	65
	12	12,5	19	Double	125	250	75	Double	115
	12,5	13,5	22	Double	150	285	90	Double	135
	13,5	17,5	22	Treble	230	425	90	Double	135

NOTES.—TABLE 52 D

1. In seams of middle line strake of inner bottom and margin plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent inner bottom plating.

2. Where oil fuel is carried in the double bottom and ceiling is not fitted completely over the inner bottom the seams and end laps are to be not less than double riveted.

3. For number of rivets between frames in seams of inner bottom plating *see* Table 52 E. The spacing of rivets in seams not parallel with the middle line of the ship is not to exceed 4 diameters. Where longitudinal framing is adopted the spacing of rivets in seams of inner bottom plating is not to exceed 4 diameters.

E

NUMBER OF RIVETS IN SEAMS OF PLATING BETWEEN FRAMES AND BEAMS EXCLUDING RIVETS IN FRAMES AND BEAMS

FRAME OR BEAM SPACING	THICKNESS OF SHELL AND DECK PLATING IN MILLIMETRES						THICKNESS OF INNER BOTTOM PLATING IN MILLIMETRES		
	Not exceeding 9	Above 9 and not exceeding 12,5	Above 12,5 and not exceeding 18,5	Above 18,5 and not exceeding 24	Above 24 and not exceeding 29	Above 29 to 32	Not exceeding 9	Above 9 and not exceeding 12,5	Above 12,5 and not exceeding 18,5
	Diameter of rivet in millimetres						Diameter of rivet in millimetres		
MILLIMETRES	16	19	22	25	28	32	16	19	22
	Number of rivets in each row						Number of rivets in each row		
510	6	5					7	6	
520	7	5					7	6	
535	7	5	5				7	6	5
545	7	6	5				7	6	5
560	7	6	5				8	6	5
570	7	6	5				8	6	5
585	7	6	5	5			8	7	6
595		6	5	5			8	7	6
610		6	5	5			8	7	6
620		6	5	5			9	7	6
635		7	6	5			9	7	6
645		7	6	5				7	7
660		7	6	5	5			8	7
675		7	6	5	5			8	7
685		7	6	5	5			8	7
695		7	6	5	5			8	7
710		7	6	5	5	5		8	7
725		8	6	6	5	5		8	7
735		8	7	6	5	5			8
750		8	7	6	5	5			8
760		8	7	6	5	5			8
775		8	7	6	5	5			8
785		9	7	6	5	5			8
800			7	6	6	5			8
815			7	6	6	5			8
825			7	6	6	5			8
840			8	7	6	5			9
850			8	7	6	5			9
865			8	7	6	6			9
875			8	7	6	6			9
890			8	7	6	6			9
900			8	7	6	6			9
915			8	7	6	6			9

F

NUMBER OF RIVETS BETWEEN FRAMES IN EACH FLANGE OF THE ANGLES CONNECTING STRINGER PLATES TO SHELL AND INTERCOSTAL GIRDERS TO SHELL AND INNER BOTTOM

FRAME SPACING		DIAMETER OF RIVET IN MILLIMETRES			
MILLIMETRES		16	19	22	25
Above	Not exceeding	NUMBER OF RIVETS			
—	610	5	4	4	
610	685	6	5	5	4
685	760	7	6	5	5
760	840		7	6	5
840	915			7	6

For strength deck stringer angles *see* Table 19.

RIVETING AND WELDING

G

TYPES OF WELDING

SIZE OF FILLET WELDS

PLATING THICKNESS	BASIC THROAT THICKNESS
mm.	mm.
6,0	4,0
7,5	4,5
9,0	5,0
10,5	5,5
12,0	6,0
14,0	6,5
16,0	7,0
18,0	8,0
20,5	9,0
23,0	10,0
25,5	11,0

NOTES.—TABLE 52 G

1. **Basic throat thickness** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of fillet will be specially considered.

2. **Basic throat thickness** for intermediate thickness to be obtained by direct interpolation.

3. **Throat thickness for double continuous fillets** is the product of Basic Throat Thickness and the Weld Factor required by Table 52 H.

4. **Throat thickness for intermittent fillets** is to be given by the formula

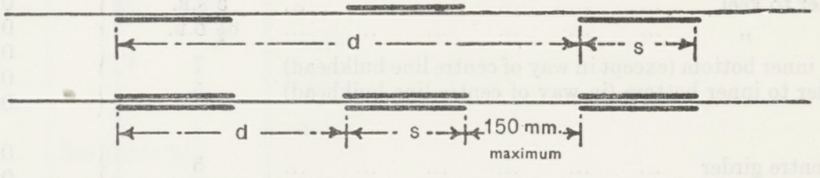
Throat thickness = Basic Throat Thickness $\times$ Weld Factor $\times \frac{d}{s}$ where s and d are as defined in the sketches below. The length s should not be less than 75 mm. and s and d are to be such that the required throat thickness does not exceed the Basic Throat Thickness.

5. **Minimum throat thickness** of fillet weld to be 0,65 of the Basic Throat Thickness except where a reduction is allowed for flat bar longitudinals. **In no case is the throat thickness to be less than 3,5 mm.**

6. **Leg length** of welds is to be 140 per cent of the throat thickness.

STAGGERED INTERMITTENT
To be doubled at ends. *See* D 3117

CHAIN INTERMITTENT



SCALLOPED FRAMES, LONGITUDINALS, STIFFENERS, etc., WITH DOUBLE FILLET WELDS

Welding to be carried round the ends of all lugs
See also D 3117.

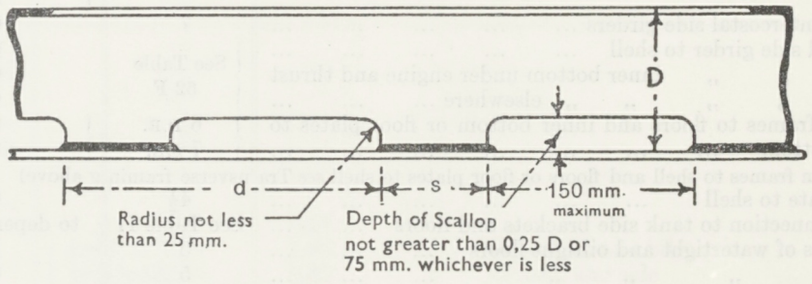


TABLE 52 H
(SEE CONTINUATION)

RIVETING AND WELDING
H
DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to 22 mm in diameter and three and a half times for rivets 25 mm. and above in diameter.

The distance from the centre of the rivet hole to the edge of the angle is to be not less than one and a half rivet diameters.

ITEM	RIVETED	WELDED	
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	WELD FACTOR	NOTES
TRANSVERSE FRAMING			
Hold frames to shell: Spacing not over 740 mm.	7	0,21	
Hold frames to shell: over 740 mm. and up to 810 mm.	6½	0,23	
Hold frames to shell: 810 „ „ 860 „	6	0,25	
Hold frames to shell: 860 „	5½	0,27	
Hold frames to shell: in deep, oil fuel and peak tanks and in panting region (D 9)	5½	0,27	
Reversed frames to frames	7		
Frames to tank side brackets—spacing not to exceed 7 diameters	See Table 11		
'Tween deck frames to shell	7	0,21	
Intermediate frames to shell	7	0,21	
Bottom frames to shell and floors or floor plates to shell: Spacing not over 810 mm.	7	0,21	no scallops in way of keel
Bottom frames to shell and floors or floor plates to shell: over 810 mm. and up to 860 mm.	6½	0,23	no scallops in way of keel
Bottom frames to shell and floors or floor plates to shell: „ „ 860 „	6	0,25	no scallops in way of keel
Bottom frames to shell and floors or floor plates to shell: in the forward 0,25L	5½	0,27 in Peaks; 0,54 elsewhere	no scallops in way of keel
Floors and cross ties to frames in fore peak	6	0,25	
„ „ „ „ aft „	5	0,30	
LONGITUDINAL FRAMING			
Bottom frames to shell and floors, or floor plates to shell (*see also* D 519)	5	0,30; 0,60	no scallops at ends
Bottom longitudinals to shell in the forward 0,25L	5½	0,27	
„ „ „ „ remainder	6	0,25	
Bottom longitudinals of flatbar type to shell			continuous weld—throat thickness 21 per cent of thickness of the thinner member being connected
DOUBLE BOTTOMS (Transversely framed)			
Centre girder to keel	5 S.R.	0,80	if watertight
„ „ „	6½ D.R.	0,60	elsewhere
„ „ inner bottom (except in way of centre line bulkhead)	7	0,80	if watertight
Centre girder to inner bottom (in way of centre line bulkhead)	5	0,50	in engine space and under thrust — no scallops
Centre girder to inner bottom (in way of centre line bulkhead)	5	0,43	elsewhere — no scallops
Floors to centre girder	5	0,60	under engine, thrust and boiler bearers
Floors to centre girder	5	0,30	elsewhere
Floors to intercostal side girders	7	0,21	
Intercostal side girder to shell	See Table 52 F	0,25	
„ „ „ inner bottom under engine and thrust	See Table 52 F	0,50	
„ „ „ „ „ elsewhere	See Table 52 F	0,21	
Reversed frames to floors and inner bottom or floor plates to inner bottom	6 D.R.	0,50	under engine and thrust
Reversed frames to floors and inner bottom or floor plates to inner bottom	7 S.R.	0,21	elsewhere
(For bottom frames to shell and floors or floor plates to shell *see* Transverse framing above)			
Margin plate to shell	4½	0,80	
Margin connection to tank side brackets and floors	See Table 11	to depend on design	generally 1,00 in panting, 0,80 elsewhere
Boundaries of watertight and oiltight floors	5	1,00	
Stiffeners „ „ „	5	0,30	
Riveting and welding in way of oil engines—To be specially considered.			

TABLE 52 H
(SEE CONTINUATION)

ITEM	RIVETED	WELDED	
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	WELD FACTOR	NOTES
DOUBLE BOTTOMS (Longitudinally framed)			
Longitudinals to inner bottom	6	0,25	
Bracket floors and longitudinal framing	See Table 8		
Floors to centre girder (*see also* D 519)	5	0,60	no scallops
,, ,, ,, when spacing of floors exceeds 2,45 metres (*see also* D 519)	5	1,00	
Reversed frames to floors and inner bottom or floor plates to inner bottom (*see also* D 519)	5	0,30 0,60	 for 2 spaces at ends with one scallop per space
SINGLE BOTTOMS			
Centre keelson to keel	5	0,60	no scallops
Reversed frames or face plates to floors	7	0,21	
(For bottom frames to shell and floors or floor plates to shell *see* Transverse framing)			
Floors to centre keelson (double riveted connection where floors cut)	4	1,00	
Foundation plates to reversed frames	4		
Continuous keelson top angles or face plates to vertical keelson plates	7	0,21	maximum—one scallop per frame space
Butts of keelsons and foundation plates	4		
Connection of reversed frames to side keelsons—not less than 2 rivets.			
Side keelsons to shell	See Table 52 F	0,25	maximum—one scallop per frame space
Riveting or welding in way of machinery—to be specially considered.			
WATERTIGHT BULKHEADS, FLATS AND TUNNELS			
Horizontal connections of plating may be single riveted.			
Vertical connections of plating and boundary angles are to be double riveted when more than 10,7 metres below the top of the bulkhead.			
Overlaps of plating	4½		
Boundary connections to shell, inner bottom and decks	5	0,80	
,, ,, ,, bulkhead	4½	0,80	
Stiffeners (except as below)	7	0,21	
Stiffeners, lugged or unattached, for 15 per cent of length at each end	4	0,38	
Brackets and lugs	See Table 36		
BULKHEADS OF DEEP TANKS, PEAK TANKS AND OIL CARGO TANKS			
Overlaps of plating and boundary angles to be single or double riveted as for watertight bulkheads.			
Overlaps of plating	4		
Stiffeners, bracketed	6	0,25	
Boundary connections	As for W.T. bulkheads	1,00 0,80	at bottom and bilge at deck and side
Brackets	See Table 36		

RIVETING AND WELDING

H

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	RIVETED	WELDED	
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	WELD FACTOR	NOTES
OIL FUEL BUNKERS			
Where not otherwise required to be increased, the overlaps of plating of bulkheads, shell and deck and the stringer angle may be single riveted if not more than 8,5 metres below the top of the overflow or 4,9 metres below the top of the tank; elsewhere the riveting is to be double.			
Centre line bulkheads may be single riveted throughout.			
Overlaps of bulkhead, inner bottom and deck plating	4		
Deck stringer connection	4	0,80	except at strength deck
Boundary connections	5 D.R.	1,00 0,80	at bottom and bilge at deck and side
Stiffeners bracketed	6	0,25	
Horizontal girders to shell and bulkheads (*see also* D 2006 to D 2010) ...	4½	0,33 0,65	clear of brackets at brackets
Horizontal girders—brackets	4½ D.R.	0,65	if overlapped
,, ,, —face angles or plates where area is less than 39 sq.cms	7	0,21	
Horizontal girders—face angles or plates where area is more than 39 sq.cms	6	0,25	
Stiffener brackets	See Table 36		
NON-WATERTIGHT BULKHEADS			
Overlaps of plating	6		
Boundary connections to inner bottom, horizontal riveted flange (*see also* D 1802)	5	0,30	no scallops
Boundary connections elsewhere	7	0,21	
Stiffeners	7	0,21	
DECKS			
Stringer angle on strength decks	See Table 19		
,, ,, lower ,, ...	,, ,, 52 F		
BEAMS AND DECK LONGITUDINALS			
Beams to deck	7	0,21	
,, at crown of deep tanks, peak tanks and oil fuel tanks	6	0,25	
Strong beams at ends of hatchways, deck connections (*see also* Deck girders)	5	0,30	
Half beams to hatch coamings and casings—lugs of same thickness as coaming with 2 rivets or 6,5 sq.cms of welding in each flange for beams not exceeding 200 mm. and 3 rivets or 9,7 sq.cms of welding for beams exceeding 200 mm. in depth.			
Longitudinals to deck	6	0,25	
Deck longitudinals of flatbar type to deck plating		0,25	In way of tanks, continuous weld—throat thickness 21 per cent of thickness of the thinner member being connected.
Beam knees	See Table 28		
DECK GIRDERS, TRANSVERSES AND WEBS			
Connections to plating (*see also* D 1505 to D 1508)	5	0,30	
Face section, not exceeding 39 sq.cms area, to web	7	0,21	
,, ,, exceeding 39 sq.cms area, to web...	6	0,25	
End brackets	5 D.R.	0,80	
Butts of girders	4		

TABLE 52 H (CONCLUDED)

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	RIVETED	WELDED	
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	WELD FACTOR	NOTES
PILLARS			
Heads and heels of solid pillars	See Table 31		
Seams of tubular pillars	5		
Riveting or welding of pillars built of rolled sections	7	0,21	
End connections of widely spaced built pillars	5	0,80	
HATCHWAYS			
Coaming to deck	5	0,80	
,, ,, at corners	$4\frac{1}{2}$	1,00	
Stiffener to coaming	7	0,21	
Horizontal stiffeners on coaming where forming watertight recess	5	0,80	
Hatch beam angles or face plates	7	0,21	
Vertical corner angles	5		
VENTILATORS			
Connection to deck (*see also* D 2403)	4	0,80	
DECKHOUSES			
Overlaps of outer casings	5		
,, inner ,, ...	6		
Foundation connections (*see also* D 1209 and D 1210)	5	0,80	
Stiffeners	7	0,21	
MASTS			
End laps are to be treble riveted and seams single riveted. Overlaps of plating	5		
RUDDERS			
Spacing of rivets in arms (*see also* D 2618)	$4\frac{1}{2}$		
STEMS AND STERNFRAMES			
Connections to shell plating: diameter of rivet with solid sections to be 6 mm. greater than required for the thickness of the plating and 3 mm. greater for castings or built frames but not to exceed 28 mm.	5		
In ships above 107 metres in length shell plating is to be connected to sternframe below the boss by three rows of rivets.			
Connection to transom plate: for ships not exceeding 91,5 metres in length by two single riveted angles, in ships above 91,5 metres in length by two double riveted angles	5		

TABLE 53 EQUIPMENT

Equipment Number (*See* D 3303)		Equipment Letter	Stockless Bower Anchors		Stockless Stream Anchor	Stud Link Chain Cable for Bower Anchors				Stream Wire or Chain		Tow Line		Mooring Lines		
						Total Length	Diameter			Minimum Length	Minimum Breaking Strength	Minimum Length	Minimum Breaking Strength	Number	Minimum Length of each Line	Minimum Breaking Strength
Exceeding	Not Exceeding		Number	Weight per Anchor			Mild Steel (Grade 1 or U 1)	Special Quality (Grade U 2)	Extra Special Quality (Grade U 3)							
				Kg.	Kg.	Metres	mm.	mm.	mm.	Metres	Kg.	Metres	Kg.		Metres	Kg.
50	70	A	2	180	60	220	14	12,5	—	80	6600	180	10000	2	160	6600
70	90	B	2	240	80	220	16	14	—	85	7500	180	10000	2	160	6600
90	110	C	2	300	100	247,5	17,5	16	—	85	8300	180	10000	2	160	6800
110	130	D	2	360	120	247,5	19	17,5	—	90	9100	180	10000	2	160	7000
130	150	E	2	420	140	275	20,5	17,5	—	90	10000	180	10000	2	160	7300
150	175	F	2	480	165	275	22	19	—	90	11000	180	10000	2	160	7600
175	205	G	2	570	190	302,5	24	20,5	—	90	12000	180	11400	2	160	8000
205	240	H	3	660	—	302,5	26	22	—	—	—	180	13200	2	160	8400
240	280	I	3	780	—	330	28	24	—	—	—	180	15300	3	160	8800
280	320	J	3	900	—	357,5	30	26	—	—	—	180	17700	3	160	9200
320	360	K	3	1020	—	357,5	32	28	—	—	—	180	21100	3	160	9600
360	400	L	3	1140	—	385	34	30	—	—	—	180	22800	3	160	10000
400	450	M	3	1290	—	385	36	32	—	—	—	180	25500	3	160	10500
450	500	N	3	1440	—	412,5	38	34	—	—	—	180	28200	3	160	11000
500	550	O	3	1590	—	412,5	40	34	—	—	—	190	31200	4	170	11500
550	600	P	3	1740	—	440	42	36	—	—	—	190	34500	4	170	12000
600	660	Q	3	1920	—	440	44	38	—	—	—	190	37800	4	170	12500
660	720	R	3	2100	—	440	46	40	—	—	—	190	41400	4	170	13000
720	780	S	3	2280	—	467,5	48	42	—	—	—	190	45000	4	170	13500
780	840	T	3	2460	—	467,5	50	44	—	—	—	190	48900	4	170	14000
840	910	U	3	2640	—	467,5	52	46	40	—	—	190	52800	4	170	14500
910	980	V	3	2850	—	495	54	48	42	—	—	190	57000	4	170	15000
980	1060	W	3	3060	—	495	56	50	44	—	—	200	61500	4	180	16000
1060	1140	X	3	3300	—	495	58	50	46	—	—	200	66000	4	180	17000
1140	1220	Y	3	3540	—	522,5	60	52	46	—	—	200	70500	4	180	18000
1220	1300	Z	3	3780	—	522,5	62	54	48	—	—	200	75300	4	180	19000
1300	1390	A†	3	4050	—	522,5	64	56	50	—	—	200	80100	4	180	20000
1390	1480	B†	3	4320	—	550	66	58	50	—	—	200	85200	4	180	21000
1480	1570	C†	3	4590	—	550	68	60	52	—	—	220	90600	5	190	22000
1570	1670	D†	3	4890	—	550	70	62	54	—	—	220	96000	5	190	23000
1670	1790	E†	3	5250	—	577,5	73	64	56	—	—	220	104400	5	190	24000
1790	1930	F†	3	5610	—	577,5	76	66	58	—	—	220	113100	5	190	25000
1930	2080	G†	3	6000	—	577,5	78	68	60	—	—	220	119100	5	190	26000
2080	2230	H†	3	6450	—	605	81	70	62	—	—	240	128400	5	200	27000
2230	2380	I†	3	6900	—	605	84	73	64	—	—	240	138300	5	200	28000
2380	2530	J†	3	7350	—	605	87	76	66	—	—	240	148200	5	200	29000
2530	2700	K†	3	7800	—	632,5	90	78	68	—	—	260	150000	6	200	30000
2700	2870	L†	3	8300	—	632,5	92	81	70	—	—	260	150000	6	200	31000
2870	3040	M†	3	8800	—	632,5	95	84	73	—	—	260	150000	6	200	32000
3040	3210	N†	3	9350	—	660	98	84	76	—	—	280	150000	6	200	33000
3210	3400	O†	3	9900	—	660	100	87	78	—	—	280	150000	6	200	34000
3400	3600	P†	3	10500	—	660	102	90	78	—	—	280	150000	6	200	35000
3600	3800	Q†	3	11100	—	687,5	105	92	81	—	—	300	150000	6	200	36000
3800	4000	R†	3	11700	—	687,5	108	95	84	—	—	300	150000	6	200	37000
4000	4200	S†	3	12300	—	687,5	111	98	87	—	—	300	150000	7	200	38000
4200	4400	T†	3	12900	—	715	114	100	87	—	—	300	150000	7	200	39000
4400	4600	U†	3	13500	—	715	—	102	90	—	—	300	150000	7	200	40000
4600	4850	V†	3	14250	—	715	—	105	92	—	—	300	150000	7	200	41000
4850	5100	W†	3	15000	—	742,5	—	108	95	—	—	300	150000	7	200	42000
5100	5400	X†	3	15800	—	742,5	—	111	98	—	—	300	150000	8	200	44000
5400	5700	Y†	3	16700	—	742,5	—	114	100	—	—	300	150000	8	200	46000
5700	6000	Z†	3	17600	—	742,5	—	117	102	—	—	300	150000	8	200	48000
6000	6300	A*	3	18500	—	742,5	—	120	105	—	—	300	150000	8	200	50000

For notes see page 191

NOTES—TABLE 53

1. A towline is not required when the length L exceeds 180 metres.

2. The rope used for stream wire is to be constructed of not less than 72 wires made up into six strands.

3. Wire ropes used for tow lines and mooring lines are to be of a flexible construction with not less than:—

72 wires in 6 strands with 7 fibre cores for strengths up to 22000 kg.

144 wires in 6 strands with 7 fibre cores for strengths of 22000 kg. to 50000 kg. inclusive.

222 wires in 6 strands with 1 fibre core for strengths exceeding 50000 kg.

4. Irrespective of strength requirements, no fibre rope is to be less than 20 mm. diameter.

5. For permitted variations in anchor weights, *see* D 3307 and D 3310.

6. Tests. *See* P 11 for anchors.
P 13 for chain cables.
P 14 for wire ropes and fibre ropes.

TABLE 54

EQUIPMENT FOR TUGS

EQUIPMENT NUMBER		STOCKLESS BOWER ANCHORS		STUD LINK CHAIN CABLE			MOORING LINES			
					Diameter				Minimum Breaking Strength	
Exceeding	Not Exceeding	Number	Weight per Anchor	Total Length	Wrought Iron or Mild Steel (Grade U 1)	Special Quality Steel (Grade U 2)	Number Required	Length of Each	First	Remainder
			Kg.	Metres	mm.	mm.		Metres	Kg.	Kg.
—	135	2	165	110	16	14	2	110	6800	2500
135	170	2	180	110	17,5	16	2	110	7500	2500
170	200	2	195	110	17,5	16	2	110	8200	2500
200	230	2	210	110	19	17,5	2	110	8900	3100
230	260	2	225	137,5	20,5	17,5	2	110	9600	3800
260	290	2	240	137,5	22	19	2	110	10200	4500
290	310	2	255	137,5	22	19	2	110	10800	5200
310	330	2	270	137,5	22	19	2	110	11300	5800
330	350	2	285	165	24	20,5	2	110	11800	6400
350	370	2	300	165	24	20,5	2	110	12300	7000
370	395	2	315	165	24	20,5	2	110	12700	7600
395	420	2	330	165	26	22	2	110	13100	8200
420	450	2	345	192,5	26	22	2	110	13500	8700
450	475	2	360	192,5	26	22	2	110	13900	9200
475	500	2	380	192,5	28	24	2	110	14300	9700
500	530	2	400	220	28	24	2	110	14800	10200
530	560	2	420	220	28	24	2	110	15200	10700
560	590	2	440	247,5	30	26	2	110	15700	11000
590	620	2	460	247,5	30	26	2	110	16100	11000
620	650	2	480	247,5	30	26	2	110	16500	11000
650	680	2	500	275	32	28	2	110	16900	11000
680	710	2	520	275	32	28	2	110	17300	11000
710	740	2	540	275	32	28	2	110	17500	11000
740	770	2	570	302,5	32	28	2	110	17700	11000
770	805	3	610	302,5	34	30	3	110	17700	11000
805	840	3	660	330	34	30	3	110	17700	11000
840	880	3	720	330	34	30	3	110	17700	11000
880	920	3	780	330	36	32	3	110	17700	11000
920	960	3	840	357,5	36	32	3	140	17700	11000
960	1000	3	900	357,5	36	32	3	140	17700	11000
1000	1060	3	1020	357,5	38	32	3	140	17700	11000
1060	1120	3	1140	385	38	34	3	140	17700	11000
1120	1180	3	1290	385	40	34	3	140	17700	11000
1180	1240	3	1440	385	40	34	3	140	17700	11000
1240	1300	3	1590	385	42	36	4	170	17700	11500

NOTES—TABLE 54

1. Where the Equipment Number exceeds 1300, the equipment is to be derived assuming a number of 1300 or from D 3303 and Table 53 (excluding the towline), whichever gives the greater value for the items under consideration.
2. If it is desired to use short link chain the diameter is to be that for which the same proof test is required as for the stud link chain given in the Table. *See* P 13, Table 4.
3. For remaining notes, *see* Table 53.

RENEWAL OF STEERING CHAINS & CHAIN CABLES WHEN WORN

When any length of a chain is so worn that the mean diameter at its most worn part is reduced to the size given in the following Table it is to be renewed.

ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
16	14,5	35	31	54	48,5	73	65
17	15,5	36	32	55	49,5	74	66
18	16	37	33	56	50	75	67
19	17	38	34	57	51	76	68
20	18	39	35	58	51,5	77	69
21	18,5	40	36	59	52,5	78	70
22	19,5	41	36,5	60	53,5	79	71
23	20,5	42	37,5	61	54,5	80	72
24	21,5	43	38,5	62	55,5	81	73
25	22,5	44	39,5	63	56,5	82	74
26	23	45	40	64	57,5	83	75
27	24	46	41	65	58	84	75,5
28	25	47	42	66	59	85	76
29	26	48	43	67	60	86	77
30	27	49	43,5	68	61	87	77,5
31	28	50	44,5	69	62	88	78,5
32	28,5	51	45,5	70	63	89	79,5
33	29,5	52	46,5	71	64		
34	30,5	53	47,5	72	64,5		

TABLE 56

(SEE CONTINUATION)

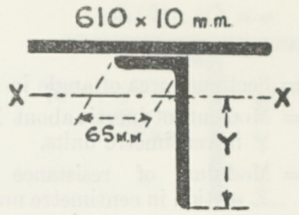
GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

ANGLES HAVIN

DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
		5,0	5,5	6,0	6,5	7,0	7,5	8,0	8,5	9,0
65	A	6,36	6,95	7,53	8,12	8,70	9,28	9,85	10,4	11,0
	I	61,7	66,4	71,1	75,8	80,5	85,4	90,3	95,7	101
	$I/_Y$	9,2	9,9	10,6	11,3	12,0	12,8	13,5	14,4	15,3
75	A	6,82	7,47	8,11	8,75	9,36	9,98	10,6	11,3	11,9
	I	85,4	93,2	101	109	116	124	132	140	147
	$I/_Y$	11,0	12,1	13,1	14,2	15,2	16,3	17,4	18,5	19,5
80	A			8,42	9,07	9,71	10,4	11,0	11,7	12,3
	I			119	128	137	146	155	164	173
	$I/_Y$			14,7	15,9	17,0	18,2	19,3	20,5	21,6
90	A			9,03	9,71	10,4	11,2	11,9	12,6	13,2
	I			165	177	188	201	213	225	236
	$I/_Y$			18,2	19,5	20,8	22,3	23,8	25,2	26,6
100	A			9,73	10,5	11,2	12,0	12,8	13,5	14,2
	I			220	235	250	268	286	300	314
	$I/_Y$			22,0	23,6	25,2	27,2	29,1	30,6	32,1
115	A			10,5	11,4	12,2	13,0	13,8	14,7	15,5
	I			319	344	368	392	416	439	462
	$I/_Y$			28,1	30,4	32,7	35,0	37,3	39,5	41,7
130	A					13,3	14,2	15,1	16,0	16,9
	I					511	545	578	611	643
	$I/_Y$					40,6	43,5	46,3	49,1	51,9

GEOMETRICAL PROPERTIES OF SECTIONS



65 mm. FLANGE

THICKNESS OF WEB IN MILLIMETRES								ITEM	DEPTH OF WEB IN MILLIMETRES
9,5	10,0	10,5	11,0	11,5	12,0	12,5	13,0		
11,6	12,1	12,7	13,2	13,6	14,0	14,7	15,3	A	65
106	110	116	122	125	128	137	145	I	
16,1	16,8	17,7	18,6	19,1	19,6	21,0	22,3	$I/_Y$	
12,5	13,1	13,7	14,3	14,9	15,5	16,1	16,6	A	75
154	161	168	176	184	192	201	210	I	
20,5	21,5	22,5	23,5	24,6	25,6	26,7	27,8	$I/_Y$	
13,0	13,6	14,2	14,8	15,4	16,0	16,7	17,3	A	80
182	191	200	208	217	225	234	242	I	
22,8	24,0	25,2	26,3	27,5	28,6	29,8	30,9	$I/_Y$	
13,9	14,6	15,3	16,0	16,7	17,4	18,0	18,6	A	90
248	260	272	284	296	308	321	334	I	
28,1	29,5	31,0	32,5	33,9	35,3	36,8	38,3	$I/_Y$	
15,0	15,7	16,4	17,1	17,8	18,5	19,2	19,9	A	100
331	347	361	375	389	403	418	433	I	
33,9	35,7	37,3	38,9	40,5	42,1	43,7	45,3	$I/_Y$	
16,3	17,1	17,9	18,7	19,5	20,3	21,1	21,9	A	115
485	507	520	533	546	559	573	587	I	
43,9	46,1	48,3	50,5	52,7	54,9	57,1	59,3	$I/_Y$	
17,8	18,6	19,5	20,4	21,3	22,1	23,0	23,9	A	130
674	704	736	768	798	827	857	887	I	
54,6	57,2	60,1	62,9	65,6	68,3	71,0	73,7	$I/_Y$	

TABLE 56
(SEE CONTINUATION)

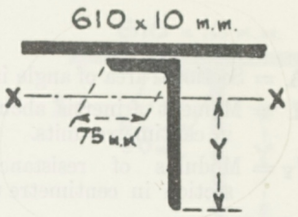
GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

ANGLES HAVING

DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
		6,0	6,5	7,0	7,5	8,0	8,5	9,0	9,5	10,0
75	A	8,79	9,45	10,1	10,9	11,5	12,2	12,8	13,5	14,1
	I	103	110	116	124	131	138	145	153	161
	$I/_Y$	13,4	14,3	15,1	16,3	17,3	18,3	19,3	20,4	21,5
90	A	9,61	10,4	11,1	11,9	12,6	13,4	14,1	14,9	15,6
	I	164	176	187	201	214	225	236	248	259
	$I/_Y$	18,1	19,5	20,8	22,4	23,9	25,3	26,6	28,0	29,3
100	A			11,9	12,8	13,6	14,4	15,1	15,9	16,7
	I			249	267	285	300	314	330	346
	$I/_Y$			25,1	27,0	28,9	30,6	32,2	33,9	35,6
120	A					15,1	16,0	16,8	17,7	18,6
	I					468	491	513	539	565
	$I/_Y$					40,3	42,4	44,5	47,0	49,4
130	A					15,9	16,9	17,8	18,7	19,6
	I					579	612	644	675	706
	$I/_Y$					46,4	49,2	52,0	54,7	57,4
140	A					16,7	17,7	18,7	19,7	20,6
	I					714	752	789	827	865
	$I/_Y$					53,4	56,5	59,6	62,7	65,8
150	A					17,5	18,5	19,5	20,6	21,6
	I					860	907	954	1000	1046
	$I/_Y$					60,5	64,1	67,7	71,3	74,9

GEOMETRICAL PROPERTIES OF SECTIONS



75 mm. FLANGE

THICKNESS OF WEB IN MILLIMETRES								ITEM	DEPTH OF WEB IN MILLIMETRES
10,5	11,0	11,5	12,0	12,5	13,0	13,5	14,0		
14,8	15,4	16,1	16,7	17,4	18,1			A	75
167	173	181	189	197	204			I	
22,4	23,2	24,4	25,6	26,7	27,7			I/y	
16,3	17,0	17,7	18,4	19,1	19,8			A	90
271	282	293	304	315	326			I	
30,8	32,2	33,5	34,8	36,1	37,4			I/y	
17,5	18,2	19,0	19,7	20,5	21,2			A	100
361	376	391	406	421	436			I	
37,3	39,0	40,7	42,4	44,1	45,8			I/y	
19,5	20,3	21,2	22,1	23,0	23,9			A	120
590	615	640	664	689	714			I	
51,8	54,1	56,5	58,9	61,3	63,7			I/y	
20,6	21,5	22,4	23,3	24,2	25,1	26,0	26,9	A	130
738	770	799	827	856	884	912	939	I	
60,3	63,1	65,7	68,3	70,9	73,5	76,1	78,7	I/y	
21,6	22,6	23,6	24,5	25,5	26,4	27,3	28,2	A	140
903	940	977	1014	1050	1086	1121	1156	I	
69,0	72,1	75,3	78,4	81,6	84,7	87,9	91,0	I/y	
22,6	23,6	24,7	25,7	26,7	27,7	28,7	29,6	A	150
1091	1136	1181	1226	1269	1311	1353	1394	I	
78,5	82,0	85,6	89,2	92,7	96,1	99,6	103	I/y	

TABLE 56
(SEE CONTINUATION)

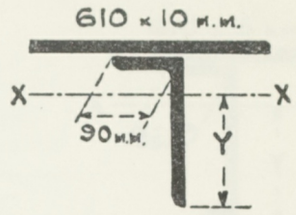
GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

ANGLES HAVING

DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES									
		7,0	7,5	8,0	8,5	9,0	9,5	10,0	10,5	11,0	11,5
90	A	12,0	12,9	13,8	14,6	15,5	16,3	17,1	17,9	18,7	19,5
	I	188	200	212	224	235	246	257	270	282	292
	$I/_Y$	20,9	22,3	23,7	25,1	26,5	27,8	29,1	30,7	32,2	33,5
100	A			14,7	15,5	16,3	17,2	18,1	18,9	19,7	20,6
	I			283	297	311	328	345	359	372	388
	$I/_Y$			28,8	30,3	31,8	33,7	35,6	37,1	38,6	40,4
110	A			15,5	16,4	17,3	18,3	19,2	20,1	20,9	21,8
	I			362	383	404	424	444	464	483	502
	$I/_Y$			33,7	35,8	37,8	39,9	42,0	44,0	45,9	48,0
120	A					18,2	19,2	20,2	21,1	22,0	23,0
	I					517	541	564	590	616	640
	$I/_Y$					44,8	47,1	49,3	51,8	54,2	56,5
130	A					19,2	20,2	21,2	22,2	23,2	24,2
	I					647	675	703	737	770	798
	$I/_Y$					52,2	54,7	57,2	60,2	63,1	65,6
140	A					20,0	21,1	22,2	23,2	24,2	25,3
	I					786	826	865	901	937	974
	$I/_Y$					59,3	62,6	65,8	68,8	71,8	75,0
150	A							23,2	24,3	25,3	26,4
	I							1044	1088	1132	1177
	$I/_Y$							74,6	78,1	81,6	85,2
180	A							26,2	27,4	28,6	29,9
	I							1734	1806	1878	1950
	$I/_Y$							105	110	115	120

GEOMETRICAL PROPERTIES OF SECTIONS



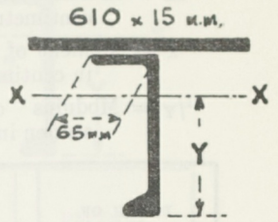
90 mm. FLANGE

THICKNESS OF WEB IN MILLIMETRES									ITEM	DEPTH OF WEB IN MILLIMETRES
12,0	12,5	13,0	13,5	14,0	14,5	15,0	15,5	16,0		
20,3	21,1	21,8	22,6	23,4	24,2	24,9	25,7	26,4	A	90
302	315	327	336	344	358	371	382	393	I	
34,7	36,3	37,8	38,9	40,0	41,7	43,4	44,8	46,1	$I/_Y$	
21,5	22,3	23,0	23,8	24,5	25,3	26,0	26,8	27,5	A	100
403	418	432	447	461	476	490	504	518	I	
42,1	43,8	45,4	47,1	48,7	50,4	52,0	53,7	55,3	$I/_Y$	
22,7	23,6	24,5	25,4	26,2	27,1	27,9	28,8	29,6	A	110
521	541	560	579	597	616	634	652	670	I	
50,0	52,0	54,0	56,0	58,0	60,0	62,0	64,0	66,0	$I/_Y$	
23,9	24,9	25,8	26,8	27,7	28,7	29,6	30,6	31,5	A	120
663	686	709	732	755	778	801	824	846	I	
58,8	61,0	63,2	65,4	67,6	69,8	72,0	74,2	76,4	$I/_Y$	
25,1	26,1	27,1	28,1	29,0	30,0	31,0	32,0	33,0	A	130
825	854	882	912	942	972	1002	1031	1060	I	
68,1	70,7	73,3	76,1	78,9	81,6	84,2	86,9	89,5	$I/_Y$	
26,3	27,3	28,3	29,4	30,4	31,4	32,4	33,5	34,5	A	140
1011	1047	1083	1118	1153	1188	1223	1258	1292	I	
78,1	81,2	84,3	87,3	90,3	93,3	96,3	99,3	102,3	$I/_Y$	
27,5	28,6	29,7	30,8	31,8	32,9	33,9	35,0	36,0	A	150
1221	1263	1305	1348	1391	1433	1475	1517	1559	I	
88,7	92,1	95,5	99,3	103	107	110	114	117	$I/_Y$	
31,1	32,4	33,6	34,8	36,0	37,2	38,4	39,6	40,8	A	180
2021	2092	2162	2231	2299	2367	2434	2502	2569	I	
125	130	135	140	145	150	155	160	165	$I/_Y$	

GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of bulb angles in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

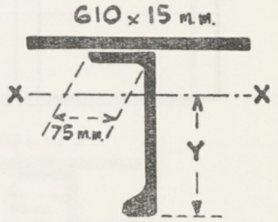
BULB ANGLES HAVING 65 mm. FLANGE



DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES						
		7,0	7,5	8,0	8,5	9,0	9,5	10,0
130	A	15,4	16,2	17,0	17,8	18,6	19,4	20,1
	I	874	914	954	993	1032	1069	1106
	$I/_Y$	68,1	71,4	74,7	78,1	81,4	84,6	87,7
140	A	16,6	17,4	18,2	19,1	19,9	20,8	21,6
	I	1111	1157	1203	1250	1296	1343	1390
	$I/_Y$	81,2	84,8	88,4	92,2	95,9	100	104

A = Sectional area of bulb angles in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

BULB ANGLES HAVING 75 mm. FLANGE



DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES										
		7,0	7,5	8,0	8,5	9,0	9,5	10,0	10,5	11,0	11,5	12,0
150	A	18,5	19,4	20,3	21,2	22,1	23,0	23,9	24,8			
	I	1406	1461	1516	1571	1627	1682	1737	1791			
	$I/_Y$	97,0	101	105	109	114	118	122	126			
165	A			22,2	23,2	24,1	25,1	26,1	27,1	28,0		
	I			2001	2070	2139	2210	2281	2349	2416		
	$I/_Y$			128	133	138	143	148	153	158		
180	A			24,2	25,3	26,3	27,4	28,4	29,5	30,5		
	I			2656	2740	2824	2912	2999	3084	3168		
	$I/_Y$			158	164	169	175	181	187	192		
200	A					29,3	30,5	31,6	32,8	33,9	35,1	36,2
	I					3919	4032	4144	4252	4359	4465	4571
	$I/_Y$					214	222	229	236	243	250	256

TABLE 56
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

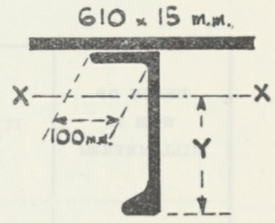
A = Sectional area of bulb angles in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

BULB ANGLES HAVING

DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
		8,0	8,5	9,0	9,5	10,0	10,5	11,0	11,5	12,0
180	A	25,5	26,6	27,7	28,8	29,9	31,0	32,1	33,1	
	I	2647	2737	2827	2917	3001	3085	3166	3247	
	$I/_Y$	157	163	169	175	181	187	192	197	
200	A					33,4	34,6	35,8	37,0	38,1
	I					4120	4234	4348	4457	4566
	$I/_Y$					227	234	241	249	256
230	A							40,8	42,2	43,5
	I							6567	6718	6869
	$I/_Y$							325	334	343
250	A							44,6	46,0	47,4
	I							8679	8871	9062
	$I/_Y$							403	414	424
280	A									53,1
	I									12690
	$I/_Y$									543
300	A									
	I									
	$I/_Y$									

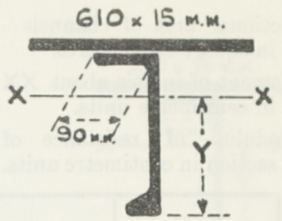
A = Sectional area of bulb angles in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

BULB ANGLES HAVING 100 mm. FLANGE



DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES										
		13,0	13,5	14,0	14,5	15,0	15,5	16,0	16,5	17,0	17,5	18,0
320	A	64,8	66,6	68,4	70,2	72,0	73,8	75,6	77,4	79,2		
	I	19080	19440	19790	20060	20330	20670	21010	21330	21650		
	$I/_Y$	737	754	771	784	797	814	831	847	862		
340	A	70,5	72,4	74,3	76,2	78,1	80,0	81,9	83,8	85,7		
	I	23840	24270	24700	25030	25360	25690	26020	26410	26790		
	$I/_Y$	888	908	928	944	959	975	991	1010	1028		
380	A				86,0	88,1	90,2	92,3	94,4	96,5	98,8	101
	I				34990	35300	35740	36170	36710	37240	37670	38100
	$I/_Y$				1217	1231	1251	1271	1295	1319	1338	1357

GEOMETRICAL PROPERTIES OF SECTIONS

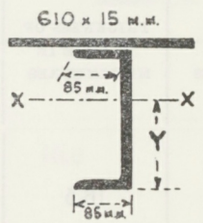


90 mm. FLANGE

THICKNESS OF WEB IN MILLIMETRES								ITEM	DEPTH OF WEB IN MILLIMETRES
12,5	13,0	13,5	14,0	14,5	15,0	15,5	16,0		
								A I $I/_Y$	180
39,3 4672 263	40,4 4778 269							A I $I/_Y$	200
44,8 7021 352	46,1 7172 360							A I $I/_Y$	230
48,9 9252 435	50,3 9442 446	51,8 9594 455	53,2 9745 463					A I $I/_Y$	250
54,7 12900 554	56,3 13110 565	57,9 13360 578	59,4 13610 591	61,0 13860 604				A I $I/_Y$	280
	60,9 16310 668	62,6 16610 683	64,2 16910 698	65,9 17150 711	67,6 17380 723	69,3 17670 738	71,0 17960 753	A I $I/_Y$	300

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

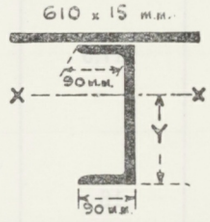
CHANNELS HAVING 85 mm. FLANGE



DEPTH OF WEB IN MILLIMETRES	THICKNESS OF FLANGE IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES						
			11,0	11,5	12,0	12,5	13,0	13,5	14,0
200	14	A I $I/_Y$	43,3 5974 346	44,3 6061 352	45,3 6148 358	46,3 6233 364	47,3 6318 370	48,3 6397 376	49,3 6476 381

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

CHANNELS HAVING 90 mm. FLANGE



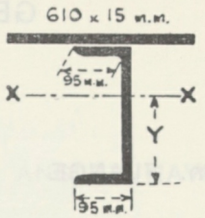
DEPTH OF WEB IN MILLIMETRES	THICKNESS OF FLANGE IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
			11,0	11,5	12,0	12,5	13,0	13,5	14,0	14,5	15,0
220	15	A I $I/_Y$	48,6 7919 424	49,7 8027 431	50,8 8134 438	51,9 8241 446	53,0 8348 453	54,1 8449 460	55,2 8549 467	56,3 8650 474	57,4 8751 480

TABLE 56
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

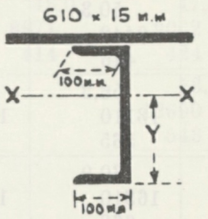
CHANNELS HAVING 95 mm. FLANGE



DEPTH OF WEB IN MILLIMETRES	THICKNESS OF FLANGE IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
			12,0	12,5	13,0	13,5	14,0	14,5	15,0	15,5	16,0
240	15,5	A	55,2	56,4	57,6	58,8	60,0	61,2	62,4	63,6	64,8
		I	10300	10440	10570	10700	10830	10960	11090	11220	11340
		$I/_Y$	516	525	533	541	549	558	566	574	582
260	16	A	58,5	59,8	61,1	62,4	63,7	65,0	66,3	67,6	68,9
		I	12560	12730	12890	13060	13220	13380	13530	13680	13830
		$I/_Y$	587	597	607	617	626	636	645	654	663

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

CHANNELS HAVING 100 mm. FLANGE

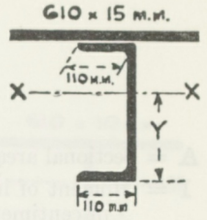


DEPTH OF WEB IN MILLIMETRES	THICKNESS OF FLANGE IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES										
			13,0	13,5	14,0	14,5	15,0	15,5	16,0	16,5	17,0	17,5	18,0
280	16,5	A	65,9	67,3	68,7	70,1	71,5	72,9	74,3	75,7	77,1		
		I	15830	16020	16210	16390	16570	16760	16950	17140	17320		
		$I/_Y$	701	712	723	734	744	755	765	776	787		
300	17	A	69,1	70,6	72,1	73,6	75,1	76,6	78,1	79,6	81,1		
		I	18700	18930	19160	19390	19620	19840	20060	20280	20490		
		$I/_Y$	779	792	804	817	829	842	854	866	877		
320	17,5	A	72,6	74,2	75,8	77,4	79,0	80,6	82,2	83,8	85,4	87,0	88,6
		I	22000	22270	22530	22800	23060	23330	23600	23850	24100	24360	24610
		$I/_Y$	869	883	896	910	923	937	950	964	978	991	1004
350	16	A	73,8	75,6	77,3	79,1	80,8	82,6	84,3	86,1	87,8	89,6	91,3
		I	26140	26480	26810	27150	27480	27840	28190	28510	28830	29170	29510
		$I/_Y$	947	963	979	995	1011	1028	1044	1060	1075	1092	1108
380	16	A	78,5	80,3	82,1	84,1	86,0	87,9	89,8	91,7	93,6	95,5	97,4
		I	32180	32590	33000	33440	33870	34290	34710	35140	35570	35990	36400
		$I/_Y$	1085	1103	1121	1141	1160	1179	1197	1216	1235	1255	1274

GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$^{I}/_{Y}$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

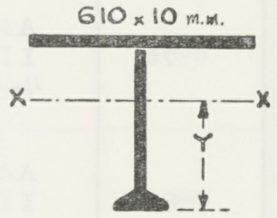
CHANNELS HAVING 110 mm. FLANGE



DEPTH OF WEB IN MILLIMETRES	THICKNESS OF FLANGE IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
			14,0	14,5	15,0	15,5	16,0	16,5	17,0	17,5	18,0
400	18	A	91,5	93,5	95,5	97,5	99,5	102	104	106	108
		I	40060	40550	41030	41500	41970	42420	42870	43330	43790
		$^{I}/_{Y}$	1319	1340	1361	1382	1402	1422	1442	1462	1482

A = Sectional area of bulb plates in square centimetres.
I = Moment of inertia about XX in centimetre units.
$^{I}/_{Y}$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

BULB PLATES



DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES									
		6,0	6,5	7,0	7,5	8,0	8,5	9,0	9,5	10,0	
130	A	10,4	11,1	11,7	12,4	13,0					
	I	809	840	870	901	931					
	$^{I}/_{Y}$	65,9	68,7	71,5	74,3	77,1					
140	A	11,0	11,7	12,4	13,1	13,8					
	I	969	1006	1042	1079	1115					
	$^{I}/_{Y}$	73,8	77,0	80,1	83,3	86,5					
160	A			14,6	15,4	16,2	17,0	17,8			
	I			1585	1637	1688	1736	1784			
	$^{I}/_{Y}$			109	113	117	121	125			
180	A					18,7	19,6	20,5	21,4	22,3	
	I					2431	2507	2582	2635	2687	
	$^{I}/_{Y}$					153	159	165	169	173	

TABLE 56
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

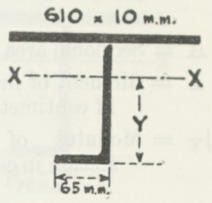
A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in centimetre units. }

INVERTED ANGLE

DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
		5,0	5,5	6,0	6,5	7,0	7,5	8,0	8,5	9,0
65	A	6,36	6,95	7,53	8,12	8,70	9,28	9,85	10,4	11,0
	I	187	201	214	228	241	252	262	274	286
	$I/_Y$	28,8	31,1	33,3	35,6	37,8	39,8	41,7	43,9	46,0
75	A	6,82	7,47	8,11	8,75	9,36	9,98	10,6	11,3	11,9
	I	252	272	291	309	325	341	357	373	389
	$I/_Y$	34,1	36,9	39,7	42,5	44,9	47,5	50,0	52,5	55,0
80	A			8,42	9,07	9,71	10,4	11,0	11,7	12,3
	I			336	355	374	393	412	430	447
	$I/_Y$			43,2	46,0	48,8	51,6	54,4	57,1	59,7
90	A			9,03	9,71	10,4	11,2	11,9	12,6	13,2
	I			431	458	485	511	537	559	581
	$I/_Y$			49,9	53,4	56,8	60,3	63,8	66,8	69,8
100	A			9,73	10,5	11,2	12,0	12,8	13,5	14,2
	I			548	583	618	650	681	711	740
	$I/_Y$			57,7	61,9	66,0	69,8	73,6	77,3	80,9
115	A			10,5	11,4	12,2	13,0	13,8	14,7	15,5
	I			745	793	841	883	924	967	1009
	$I/_Y$			69,0	74,0	78,9	83,4	87,9	92,5	97,1
130	A					13,3	14,2	15,1	16,0	16,9
	I					1120	1178	1235	1289	1343
	$I/_Y$					94,2	100	105	111	116

GEOMETRICAL PROPERTIES OF SECTIONS

HAVING 65 mm. FLANGE



THICKNESS OF WEB IN MILLIMETRES								ITEM	DEPTH OF WEB IN MILLIMETRES
9,5	10,0	10,5	11,0	11,5	12,0	12,5	13,0		
11,6	12,1	12,7	13,2	13,6	14,0	14,7	15,3	A	65
296	306	316	325	332	338	347	355	I	
47,8	49,6	51,4	53,2	54,5	55,7	57,4	59,0	$I/_Y$	
12,5	13,1	13,7	14,3	14,9	15,5	16,1	16,6	A	75
404	418	432	446	460	474	488	501	I	
57,4	59,7	62,1	64,4	66,7	68,9	71,1	73,2	$I/_Y$	
13,0	13,6	14,2	14,8	15,4	16,0	16,7	17,3	A	80
464	481	496	510	524	537	552	567	I	
62,3	64,9	67,2	69,4	71,6	73,8	76,2	78,6	$I/_Y$	
13,9	14,6	15,3	16,0	16,7	17,4	18,0	18,6	A	90
604	626	649	671	694	716	738	760	I	
72,9	76,0	79,0	82,0	84,9	87,8	90,7	93,6	$I/_Y$	
15,0	15,7	16,4	17,1	17,8	18,5	19,2	19,9	A	100
768	795	821	846	872	897	922	947	I	
84,4	87,9	91,2	94,5	97,8	101	105	108	$I/_Y$	
16,3	17,1	17,9	18,7	19,5	20,3	21,1	21,9	A	115
1047	1085	1123	1161	1198	1235	1271	1307	I	
102	106	111	115	120	124	129	133	$I/_Y$	
17,8	18,6	19,5	20,4	21,3	22,1	23,0	23,9	A	130
1393	1443	1491	1538	1582	1625	1668	1710	I	
121	126	131	136	141	146	151	156	$I/_Y$	

TABLE 56
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

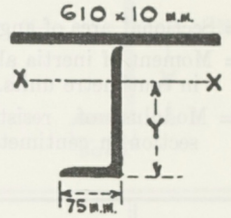
A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

INVERTED ANGL

DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
		6,0	6,5	7,0	7,5	8,0	8,5	9,0	9,5	10,0
75	A	8,79	9,45	10,1	10,9	11,5	12,2	12,8	13,5	14,1
	I	321	341	360	382	397	414	430	446	461
	$I/_Y$	44,3	47,3	50,3	53,7	56,2	58,9	61,5	64,1	66,7
90	A	9,61	10,4	11,1	11,9	12,6	13,4	14,1	14,9	15,6
	I	473	502	531	557	583	609	635	661	686
	$I/_Y$	55,2	59,1	62,9	66,5	70,0	73,6	77,1	80,8	84,4
100	A			11,9	12,8	13,6	14,4	15,1	15,9	16,7
	I			675	710	744	776	807	837	867
	$I/_Y$			72,7	77,1	81,4	85,4	89,3	93,2	97,1
120	A					15,1	16,0	16,8	17,7	18,6
	I					1110	1159	1208	1255	1302
	$I/_Y$					103	108	113	119	124
130	A					15,9	16,9	17,8	18,7	19,6
	I					1335	1393	1451	1504	1557
	$I/_Y$					115	121	127	133	138
140	A					16,7	17,7	18,7	19,7	20,6
	I					1592	1655	1718	1781	1844
	$I/_Y$					129	135	141	147	153
150	A					17,5	18,5	19,5	20,6	21,6
	I					1848	1927	2005	2083	2160
	$I/_Y$					140	147	154	161	168

GEOMETRICAL PROPERTIES OF SECTIONS

HAVING 75 mm. FLANGE



THICKNESS OF WEB IN MILLIMETRES								ITEM	DEPTH OF WEB IN MILLIMETRES
10,5	11,0	11,5	12,0	12,5	13,0	13,5	14,0		
14,8	15,4	16,1	16,7	17,4	18,1			A	75
475	489	502	515	530	545			I	
69,1	71,5	73,8	76,1	78,8	81,4			$I/_Y$	
16,3	17,0	17,7	18,4	19,1	19,8			A	90
706	726	747	767	788	808			I	
87,4	90,3	93,3	96,3	99,3	102			$I/_Y$	
17,5	18,2	19,0	19,7	20,5	21,2			A	100
895	922	947	972	985	997			I	
101	105	108	111	114	117			$I/_Y$	
19,5	20,3	21,2	22,1	23,0	23,9			A	120
1343	1383	1425	1466	1508	1549			I	
129	133	138	143	148	153			$I/_Y$	
20,6	21,5	22,4	23,3	24,2	25,1	26,0	26,9	A	130
1609	1660	1709	1757	1806	1854	1903	1951	I	
144	149	155	160	166	171	176	182	$I/_Y$	
21,6	22,6	23,6	24,5	25,5	26,4	27,3	28,2	A	140
1906	1968	2023	2078	2133	2187	2241	2295	I	
159	165	171	177	183	188	194	199	$I/_Y$	
22,6	23,6	24,7	25,7	26,7	27,7	28,7	29,6	A	150
2229	2297	2367	2436	2498	2560	2617	2674	I	
175	181	188	195	201	207	213	219	$I/_Y$	

TABLE 56

(SEE CONTINUATION)

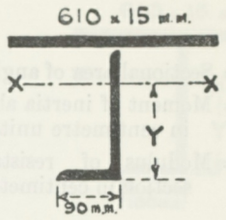
GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in centimetre units. }

INVERTED ANGLE

DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES									
		7,0	7,5	8,0	8,5	9,0	9,5	10,0	10,5	11,0	11,5
90	A	12,0	12,9	13,8	14,6	15,5	16,3	17,1	17,9	18,7	19,5
	I	674	711	748	785	822	853	883	914	945	973
	$I/_Y$	75,6	80,3	85,0	89,7	94,4	98,7	103	107	111	115
100	A			14,7	15,5	16,3	17,2	18,1	18,9	19,7	20,6
	I			941	983	1024	1064	1104	1142	1179	1217
	$I/_Y$			97,5	102	107	112	117	122	126	131
110	A			15,5	16,4	17,3	18,3	19,2	20,1	20,9	21,8
	I			1158	1209	1260	1313	1365	1409	1453	1497
	$I/_Y$			110	116	121	127	133	138	143	148
120	A					18,2	19,2	20,2	21,1	22,0	23,0
	I					1518	1583	1647	1699	1750	1806
	$I/_Y$					135	142	148	154	159	165
130	A					19,2	20,2	21,2	22,2	23,2	24,2
	I					1812	1887	1962	2028	2093	2156
	$I/_Y$					150	157	164	171	177	184
140	A					20,0	21,1	22,2	23,2	24,2	25,3
	I					2132	2220	2307	2386	2465	2540
	$I/_Y$					165	173	181	188	195	202
150	A							23,2	24,3	25,3	26,4
	I							2694	2786	2877	2964
	$I/_Y$							199	207	214	222
180	A							26,2	27,4	28,6	29,9
	I							4054	4193	4332	4467
	$I/_Y$							254	265	275	285

GEOMETRICAL PROPERTIES OF SECTIONS



HAVING 90 mm. FLANGE

THICKNESS OF WEB IN MILLIMETRES									ITEM	DEPTH OF WEB IN MILLIMETRES
12,0	12,5	13,0	13,5	14,0	14,5	15,0	15,5	16,0		
20,3	21,1	21,8	22,6	23,4	24,2	24,9	25,7	26,4	A	90
1001	1026	1051	1075	1099	1124	1148	1169	1190	I	
118	122	125	129	132	136	139	142	145	I/Y	
21,5	22,3	23,0	23,8	24,5	25,3	26,0	26,8	27,5	A	100
1254	1285	1315	1343	1370	1393	1415	1433	1450	I	
135	139	143	148	152	157	161	166	170	I/Y	
22,7	23,6	24,5	25,4	26,2	27,1	27,9	28,8	29,6	A	110
1541	1584	1626	1665	1703	1736	1768	1796	1823	I	
153	158	163	168	172	177	182	187	192	I/Y	
23,9	24,9	25,8	26,8	27,7	28,7	29,6	30,6	31,5	A	120
1861	1915	1968	2020	2071	2120	2169	2215	2261	I	
171	177	182	188	193	199	204	210	215	I/Y	
25,1	26,1	27,1	28,1	29,0	30,0	31,0	32,0	33,0	A	130
2218	2282	2346	2401	2456	2511	2566	2621	2676	I	
190	197	203	209	214	220	226	232	238	I/Y	
26,3	27,3	28,3	29,4	30,4	31,4	32,4	33,5	34,5	A	140
2615	2685	2755	2825	2894	2963	3032	3100	3168	I	
209	216	223	230	236	243	249	256	262	I/Y	
27,5	28,6	29,7	30,8	31,8	32,9	33,9	35,0	36,0	A	150
3051	3139	3227	3304	3380	3452	3524	3591	3657	I	
230	238	246	253	259	266	273	280	287	I/Y	
31,1	32,4	33,6	34,8	36,0	37,2	38,4	39,6	40,8	A	180
4601	4736	4870	4984	5097	5207	5317	5422	5527	I	
295	306	316	325	334	343	352	361	370	I/Y	

TABLE 56
(CONCLUDED)

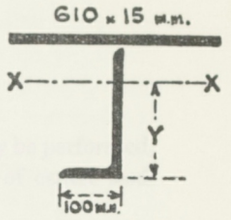
GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in centimetre units. }

INVERTED ANGLE

DEPTH OF WEB IN MILLIMETRES	ITEM	THICKNESS OF WEB IN MILLIMETRES								
		8,0	8,5	9,0	9,5	10,0	10,5	11,0	11,5	12,0
100	A	15,5	16,4	17,3	18,3	19,2	20,1	20,9	21,8	22,7
	I	1008	1055	1102	1148	1193	1231	1269	1308	1346
	$I/_Y$	105	111	116	122	127	132	137	142	147
120	A	17,3	18,2	19,2	20,1	21,1	22,1	23,1	24,1	25,1
	I	1548	1601	1654	1708	1762	1817	1872	1928	1984
	$I/_Y$	136	142	148	154	160	166	172	178	184
130	A	18,1	19,2	20,2	21,2	22,1	23,3	24,4	25,4	26,3
	I	1797	1870	1942	2014	2085	2161	2237	2302	2367
	$I/_Y$	148	155	162	169	176	184	191	198	204
140	A					23,2	24,3	25,3	26,4	27,5
	I					2455	2538	2621	2702	2782
	$I/_Y$					194	202	209	217	225
150	A					24,2	25,4	26,5	27,6	28,7
	I					2863	2963	3063	3155	3246
	$I/_Y$					213	222	230	239	247
160	A					25,2	26,4	27,6	28,8	29,9
	I					3368	3461	3554	3650	3746
	$I/_Y$					239	246	253	261	269
170	A					26,2	27,5	28,7	29,9	31,1
	I					3776	3902	4028	4154	4280
	$I/_Y$					251	261	271	281	291
200	A					29,2	30,6	32,0	33,4	34,8
	I					5466	5655	5844	6025	6206
	$I/_Y$					314	327	340	353	366

GEOMETRICAL PROPERTIES OF SECTIONS



HAVING 100 mm. FLANGE

THICKNESS OF WEB IN MILLIMETRES								ITEM	DEPTH OF WEB IN MILLIMETRES
12,5	13,0	13,5	14,0	14,5	15,0	15,5	16,0		
23,6	24,5	25,4	26,2	27,1	27,9	28,8	29,6	A	100
1382	1417	1449	1481	1510	1539	1568	1596	I	
152	156	160	164	168	172	176	180	I/y	
26,1	27,1	28,1	29,0	30,0	30,9	31,9	32,7	A	120
2041	2098	2149	2199	2248	2297	2345	2392	I	
190	196	202	208	214	220	226	232	I/y	
27,5	28,6	29,5	30,4	31,4	32,4	33,4	34,4	A	130
2440	2512	2566	2619	2668	2716	2760	2803	I	
212	219	225	231	237	242	247	252	I/y	
28,6	29,7	30,7	31,8	32,8	33,9	34,9	36,0	A	140
2861	2940	3017	3094	3169	3244	3317	3389	I	
233	240	247	254	261	267	273	279	I/y	
29,9	31,0	32,1	33,2	34,3	35,4	36,5	37,6	A	150
3335	3424	3509	3594	3670	3746	3824	3902	I	
255	263	271	279	287	294	302	309	I/y	
31,1	32,2	33,4	34,6	35,8	36,9	38,1	39,2	A	160
3845	3944	4047	4150	4242	4334	4422	4510	I	
278	286	296	305	314	322	330	338	I/y	
32,4	33,6	34,8	36,0	37,2	38,4	39,6	40,8	A	170
4396	4512	4628	4743	4858	4973	5086	5198	I	
301	311	321	330	339	348	357	365	I/y	
36,2	37,6	39,0	40,3	41,7	43,0	44,4	45,7	A	200
6382	6557	6708	6859	7018	7177	7326	7475	I	
379	391	403	414	426	438	449	460	I/y	

OIL TANKERS

Section 40

GENERAL

Application

4001 The following Rules apply to the Class 100A1 Oil Tanker. (*See* B 103.) The scantlings and arrangements of tankers intended for cargoes other than petroleum will be specially considered in relation to the nature and density of the cargo.

Sections D 1 to D 33 apply to tankers except as otherwise required by the following Rules.

For scantling reductions when higher tensile steel complying with P 219 to P 227 is used, *see* D 65, D 66 and D 67.

Method of Construction

4002 The following Rules and Tables give requirements for welded construction with certain modifications when riveting is adopted.

Structural Design

4003 The Rules apply to single deck tankers of 91,5 metres in length and over with machinery aft and having two or more longitudinal bulkheads.

The bottom and deck are to be framed longitudinally in the cargo tank spaces; the Rules assume longitudinal framing at the sides and longitudinal bulkheads where the length of the ship exceeds 198 metres, but alternative designs will be considered.

If the proportion of length to depth exceeds sixteen or the ratio of breadth to depth exceeds 2,1, increased scantlings may be required.

4004 The length of a tank is not to exceed 0,2L. When the length exceeds 0,1L or 15,25 metres, whichever is the greater, a transverse wash bulkhead is to be fitted at about the mid-length of the tank.

Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, additional transverse strengthening is to be fitted at about the mid-distance between the bulkheads. (*See* D 4605, D 4609, D 4615, D 5012 and D 5026.)

4005 A centre line bulkhead, which may be perforated, generally to be fitted when the breadth of centre tank exceeds:—

(a) 18,3 metres when the breadth B does not exceed 35,05 metres,

(b) $\left(\frac{56{,}45+B}{5}\right)$ metres when the breadth B exceeds 35,05 metres.

4006 Where a centre line bulkhead is not required by 4005, but the breadth of centre tank exceeds:—

(a) 15,24 metres when the breadth B does not exceed 35,05 metres,

(b) $\left(\frac{25{,}91+B}{4}\right)$ metres when the breadth B exceeds 35,05 metres,

the bottom and deck side girders in the centre tank are to be continuous and of increased scantlings (*see* D 4812 and D 4823). Side girders in the wing tanks, if intercostal, are also to be of increased scantlings (*see* D 4815 and D 4825).

4007 Where (i) the breadth B exceeds 38,1 metres, (ii) only two longitudinal bulkheads are required and (iii) the breadth of centre tank exceeds $\frac{B}{3}$, the continuous bottom and deck centre line girders are to be of increased scantlings (*see* D 4805 and D 4820).

The bottom and deck side girders in the wing tanks are to be continuous.

Loading

4008 Any dry tanks, or tanks intended for water ballast only and thus empty in the loaded condition, are to be indicated on the plans submitted for approval and the arrangements are to be such that these tanks cannot be used for any other purpose.

4009 In order to guard against high stresses being imposed through an unsatisfactory cargo or ballast loading it is recommended that tankers be supplied with an approved instrument for determining suitable loading.

Quality of Material

4010 Where the thickness of plating exceeds 20,5 mm. and the seams and butts are welded, steel of grade D (*see* P 2, Table II) will generally be required for the following parts of the structure:—

(*a*) Sheerstrake, strength deck stringer and plating, top strake of the longitudinal bulkhead, deck longitudinals of the slab type where cut from plates and through brackets for deck longitudinals.

This grade D plating is to extend from 0,15L aft of amidships to 0,15L forward of amidships where the length is 152,4 metres and below, and from 0,2L aft of amidships to 0,2L forward of amidships where the length is 213,4 metres and above, with intermediate values obtained by interpolation, always provided that the forward limit extends at least 3 metres forward of the bridge front.

In addition, the sheerstrake and strength deck stringer and plating are to be of grade D in way of the poop front, extending forward to cover any pump room openings. Any stringer, deck or sheerstrake plating between the above after limit of the midship portion and 0,25L aft of amidships which is above 25,5 mm. in thickness should also be of grade D.

Any sheerstrake or stringer plate outside the above limits which exceeds 25,5 mm. in thickness should also be grade D.

Face flats of deck longitudinals or girders are to be of grade D if exceeding 35,5 mm. in thickness.

(*b*) Bottom shell plating to upper turn of bilge, bottom strake of the longitudinal bulkhead, bottom longitudinals of the slab type cut from plates and through brackets of bottom longitudinals.

This grade D plating is to extend from 0,15L aft of amidships to 0,15L forward of amidships where the length is 152,4 metres and below, and from 0,25L aft of amidships to 0,2L forward of amidships where the length is 213,4 metres and above with intermediate values obtained by interpolation.

In addition, the bottom plating between the above after limit and 0,25L aft of amidships is to be of grade D where the thickness is above 25,5 mm.

Where the bottom plating is required to be of steel of the above grade, the keel plate is also to be of the same grade.

Face flats of bottom longitudinals or girders are to be of grade D if exceeding 35,5 mm. in thickness.

4011 Strakes of grade E steel are to be arranged as follows:—

LENGTH L		Grade E Strakes
Over	Not exceeding	
Metres	Metres	
213,4	228,6	Bilge strake
228,6	243,8	Bilge strake Sheerstrake
243,8	259,1	Bilge strake Sheerstrake Bottom strake in way of longitudinal bulkhead
259,1		As for tankers over 243,8 metres with the addition of the keel The deck strake in way of the longitudinal bulkhead is also to be grade E unless the top strake of the bulkhead is grade D

The fore and aft extent of the grade E strakes is to be as follows:—

(a) Sheerstrake and deck plating from within the poop to 0,2L forward of amidships.

(b) Bottom and bilge plating from 0,25L aft of amidships to 0,2L forward of amidships.

The breadth of each strake is not to be less than 1525 mm. except that the bilge strake shall not be less than 1835 mm.

Any plates in the deck or bottom exceeding 35,5 mm. in thickness are to be grade E.

The use of riveted seams as an alternative to strakes of grade E steel will be specially considered.

Cofferdams and Below Deck Passages or Tunnels

4012 Cofferdams are to be provided at the forward and after ends of the oil cargo spaces; cofferdams are to be at least 760 mm. in length and are to cover the whole area of the end bulkheads of the cargo spaces.

Pump rooms or water ballast tanks will be accepted in lieu of a cofferdam. An oil fuel bunker will also be accepted provided the bulkhead between it and the cargo tank is completely welded.

(The attention of the Owners should be drawn to the Suez Canal Authorities' requirement that only pump rooms or water ballast tanks can be accepted in lieu of a cofferdam.)

A cofferdam is also to be arranged between a cargo oil tank and accommodation spaces or between a cargo oil tank and spaces containing electrical equipment other than spaces where the only electrical equipment is lighting

fittings complying with M 1604. (*See also* M 1605.) Where the bridge 'tween deck acts as a cofferdam any access to this 'tween deck from the deck above is to be from the open deck.

Passages or tunnels passing through, or adjacent to, a cargo oil tank and not separated from it by a cofferdam are to be provided with mechanical ventilation, and any access is to be from the open deck.

Freeing Arrangements and Gangway

4013 Ships with bulwarks are to have open rails fitted for at least half the length of the exposed part of each well.

A strong permanent fore and aft gangway is to be fitted at the level of the superstructure decks. Where there is no accommodation forward, the gangway between the bridge and forecastle may be omitted and where there is no midship erection and all accommodation, etc., is aft, the gangway may be omitted entirely. Arrangements are, however, to be made to give safe access to the fore end of the ship.

Submission of Plans

4014 In addition to the plans required by D 108, plans showing the construction of the transverse and longitudinal oiltight bulkheads, end connections for all longitudinals and other framing members, the structure at the ends of the ship, deckhouses protecting machinery casings and arrangements at the junction of transverse and longitudinal framing are also to be submitted.

A plan showing the arrangement and sequence of erection of the fabrication units is to be submitted.

4015 The information required by D 41 is to be forwarded when the midship section is submitted.

Anodes in Tanks

4016 When anodes are fitted in tanks they are to be of approved design and securely attached to the structure, both initially and during service. A plan showing the details of design and attachment and the location of the anodes is to be submitted.

Magnesium anodes are only permitted in tanks intended solely for water ballast.

Fittings in Tanks

4017 Ladders, pipe hangers and other fittings in the cargo tanks and pump rooms are to be securely fastened to the structure.

Corrosion Control

4018 When an approved system of corrosion control is installed the reduction in thickness given below will be allowed. Where reductions are desired at the top of the tank within 1,525 metres of the deck at side, this part of the tank is to be coated but other approved systems may be used for the remainder of the tank.

When reductions have been effected a notation will be made in the Register Book.

ITEM	PERMISSIBLE REDUCTION IN THICKNESS
Plating and stiffeners of transverse and longitudinal bulkheads. Bottom, side and deck transverses. Transverse side framing. Vertical webs and horizontal girders. Cross ties.	10 per cent
Keel. Bottom and side shell. Deck plating. Bottom, side and deck longitudinals. Bottom and deck centreline and side girders.	5 per cent

The minimum thickness of keel, bottom and deck plating given in D 4302, D 4301 and D 4201 respectively may be reduced by 5 per cent. The minimum thickness of the remaining items may be 1,0 mm. less than the minimum given in D 5308 and D 5309.

Special consideration will be given to the extent of protection required in tankers intended solely for the carriage of crude oil.

The plans of midship section, profile and decks and shell expansion should indicate both the rule scantlings and the thicknesses proposed.

Section 41

LONGITUDINAL STRENGTH

4101 The section modulus at keel is not to be less than the greater of the following values:—

(a) M cm.^{3}

(b) $\frac{M}{3} + 130\ SWBM$ cm.^{3}

where $M = 0{,}96kB(C_b+0{,}70)\times10^5$ cm.^{3}

k is to be determined from Table 60

C_b is the moulded block coefficient at load draught. Where the block coefficient is less than 0,75, a value equal to $\left(\frac{C_b + 0{,}75}{2}\right)$ is to be used. The block coefficient is to be determined using the length L as defined in D 201.

B is the moulded breadth, in metres.

SWBM is the maximum still water bending moment (in tonnes metres) hogging or sagging (*see* 4104 and 4105).

NOTE.—When the required section modulus is the minimum acceptable, i.e. that given by (a) above, the maximum permissible still water bending moment will be $5{,}1\ M\times10^{-3}$ tonnes metres which corresponds to a stress of 5,1 kg. per mm.^{2}

4102 The section modulus at deck is not to be less than 97 per cent of the required section modulus at keel.

4103 The midship deck and bottom areas may be determined from Table 61 and Notes. The area derived from the Table and Notes is the bottom area. The deck area is to be 95 per cent of the corrected bottom area.

Alternatively, a direct calculation of section modulus may be carried out (*see* 4108).

4104 The still water bending moment is to be calculated for the homogeneous loaded condition (excluding dry tanks and tanks used solely for water ballast) and for the ballast conditions. The calculations are to be submitted.

4105 Where in loaded or ballast conditions the load is not uniformly distributed over the cargo tank length, curves of still water bending moment and shear force are to be submitted. The method of calculating these curves is to be submitted together with the assumed longitudinal distribution of lightship weight.

4106 Calculations of still water bending moment are to be carried out with oil fuel, fresh water and stores distributed as follows:—

(a) OIL FUEL. A quantity equal to one half the total available capacity of oil fuel tanks, including dual purpose oil fuel/water ballast tanks.

(b) FRESH WATER. All fresh water tanks are to be taken as full.

(c) STORES. A weight equal to $\left(\frac{W}{1000} + 100\right)$ tonnes where W is the moulded displacement in tonnes at the summer load waterline.

For loaded conditions, the ship is to be assumed at the load draught with the above quantities of oil fuel, fresh water and stores.

4107 When the still water bending moment is required to be calculated for conditions other than homogeneous load conditions, the approved loading is to be incorporated in the Loading Manual.

4108 Where a direct calculation of midship section modulus is carried out all continuous longitudinal material is to be included in the calculation of the inertia of the section, and the lever "y" is to be measured from the neutral axis to the top of the keel and to the moulded deck line at side (see also Note 4 to Table 61).

The section modulus calculation is to be forwarded with the midship section.

Section 42

DECKS

Strength Deck

4201 The thickness of deck plating amidships is to be that necessary to give the section modulus required by D 4101, but is not to be less than:—

$$\frac{s}{3570}\left(L_1 + 75\right)\sqrt{\frac{d}{L_1}}\ \text{mm.}$$

where s = spacing of longitudinals, in mm.,

L_1 = length of ship, in metres, but need not be taken as greater than 250 metres,

d = moulded draught, in metres, but is not to be taken as less than 0,05L.

The midship thickness is to be maintained from 0,2L aft of amidships to 0,2L forward of amidships and is to be gradually tapered to the end thickness. The midship thickness may be required over an increased extent if shown to be necessary by the bending moment curves.

4202 The thickness at the poop front is to extend into the poop for a distance at least equal to one-third the breadth B.

Where the machinery opening extends forward beyond a point one-third of the breadth B abaft the poop front, and the width of the casing exceeds one-half the breadth of the ship at the poop front, the thickness of deck plating may require to be increased. The forward corners of the casing opening are to be well rounded.

4203 The thickness of the stringer plate at the ends of the bridge is to be increased by 20 per cent.

If the poop front extends within 0,25L from amidships the stringer plate at the break is to be increased by 20 per cent. No increase is required if the poop front is 0,3L from amidships or greater. The increase at intermediate lengths is to be obtained by interpolation and is to be applied to the tapered thickness of the stringer plate.

The increase in thickness need not exceed 5 mm.

4204 The thickness of the deck stringer and plating for 0,05L at the fore end and 0,1L at the aft end is not to be less than $6,0 + \frac{L}{48}$ mm.

4205 If a stringer angle is fitted, in way of the cargo tanks and for at least one-third of the breadth B within the poop it is to have 150 mm. flanges when the length L does not exceed 137 metres, 180 mm. flanges for lengths exceeding 137 metres and not exceeding 167,5 metres and 200 mm. flanges above 167,5 metres. The thickness is to be that of the sheerstrake or stringer whichever is less. Alternative riveted connections will be specially considered.

At the ends of the ship the scantlings of stringer angle are to be determined from Table 19.

If the stringer angle is cut at the scuppers, compensation is to be provided. (*See also* D 4311).

4206 Where a rounded sheerstrake is incorporated the radius should, in general, not be less than 15 times the thickness. The radius should be made by careful cold rolling or bending. Where grade E plates are subjected to severe cold working or where local heating of the plates is adopted, the plates may require to be re-normalised.

4207 The corners of all deck openings are to be well rounded and smooth, and strength is to be maintained in way of pump room entrances or other openings but compensation will not, in general, be required for small elliptical openings (*see* Note 4 to Table 61) nor forward of 0,2L forward of amidships nor abaft the poop front bulkhead. It is recommended that compensation for deck openings should be in the form of an increased thickness of plating, but alternative methods will be specially considered.

Lower Decks

4208 The scantlings and arrangements of lower decks are to be as required by D 11, D 14 and D 15.

4209 Abrupt discontinuities at the ends of lower decks and flats are to be avoided by suitable tapering of the stringer plates or by fitting large brackets.

Section 43

SHELL PLATING

Bottom Shell and Keel

4301 The thickness of bottom shell plating amidships is to be that necessary to give the section modulus required by D 4101, but is not to be less than:—

$$\frac{s}{2850}\left(L_1 + 75\right)\sqrt{\frac{d}{L_1}} \text{ mm.}$$

where s = spacing of longitudinals, in mm.,

L_1 = length of ship, in metres, but need not be taken as greater than 250 metres,

d = moulded draught, in metres, but is not to be taken as less than 0,05L.

The midship thickness is to be maintained from 0,2L aft of amidships to 0,2L forward of amidships and is to be gradually tapered to the end thickness. The midship thickness may be required over an increased extent if shown to be necessary by the bending moment curves.

4302 The width and thickness of the keel over the whole length are not to be less than the values derived from the following formulæ, nor is the thickness to be less than that of the adjacent shell plating.

Width = 70B mm. but need not exceed 1800 mm.

$$\text{Thickness} = 7,5 + \frac{L_1}{10} \text{ mm.}$$

where B = moulded breadth, in metres,

L_1 = length of ship, in metres, but need not be taken as greater than 250 metres.

Bilge Plating

4303 The thickness of the bilge plating is not to be less than that determined from 4301 using an equivalent spacing s_1:—

$$s_1 = Kl \text{ mm.}$$

where $K = 1,06 - 0,39\frac{l}{R}$, but need not exceed 1,0.

s_1 is to be calculated for each panel of bilge plating (using values of l and R determined as given below) and the greatest value is to be used.

(*a*) Between adjacent longitudinals within the bilge:—

R = r mm.,

l = distance between adjacent longitudinals, in mm.

(*b*) Between lowest side longitudinal and top bilge longitudinal:—

$$R = \frac{r}{1 - \left(\frac{b - r}{l}\right)} \text{ mm.,}$$

l = distance between lowest side longitudinal and top bilge longitudinal, in mm.

(*c*) Between outboard bottom longitudinal and lowest bilge longitudinal:—

$$R = \frac{r}{1 - \left(\frac{a - r}{l}\right)} \text{ mm.,}$$

l = distance between outboard bottom longitudinal and lowest bilge longitudinal, in mm.

In (*a*), (*b*) and (*c*) above

r = radius of bilge, in mm.,

a = horizontal distance between ship's side and outboard bottom longitudinal, in mm.,

b = vertical distance between ship's bottom and lowest side longitudinal, in mm.

NOTES:—

1 The values of a and b are not to be taken as less than r.

2 l is to be measured in a straight line between the intersections of the longitudinals and the plating.

Side Shell

4304 Within 0,25L forward and 0,25L aft of amidships the thickness of side shell is not to be less than $\frac{3,66}{10^7}$ (L+1219) (d+9,14) (s+1016) mm. where L and d are as defined in D 201 and D 204 respectively, and s is the spacing of side longitudinals or side framing (as appropriate) in mm. In no case is the value of s used in this formula to be less than (559+1,11L) mm.

4305 The midship thickness of side shell is to be gradually tapered to the end thickness. (*See* 4308).

4306 Where the shear force has to be investigated (*see* D 4105), the shear stress at the neutral axis is to be calculated as:—

$$\frac{100F \times A\bar{y}}{I \times t} \text{ kg. per mm.}^2$$

where F = shear force in still water, in tonnes, taking into account, where applicable, local forces at transverse bulkheads,

$A\bar{y}$ = first moment of area of the longitudinal material above the neutral axis, in cm.^{3},

I = moment of inertia of the transverse section in cm.^{4},

t = combined thickness, in mm., of side shell and longitudinal bulkheads for both sides of the ship at the neutral axis.

4307 If the shear stress at any point along the ship's length exceeds the value derived from the table below, then the side shell in way is to be increased in thickness or, where specially approved, stiffened by intermediate frames:—

STATION	SHEAR STRESS	STATION	SHEAR STRESS
	Kg. per mm.^{2}		Kg. per mm.^{2}
AP	7,50	5½	6,95
½	7,10	6	6,55
1	6,70	6½	6,15
1½	6,30	7	5,90
2	6,05	7½	5,90
2½	5,90	8	6,05
3	6,00	8½	6,40
3½	6,20	9	6,85
4	6,60	9½	7,25
4½	7,10	FP	7,50
5	7,50	—	—

End Thickness

4308 The thickness of shell plating for 0,05L at the fore end and 0,1L at the aft end is not to be less than:—

$$6,5 + \frac{L}{30} \text{ mm.}$$

Sheerstrake

4309 The width of sheerstrake from 0,25L aft of amidships to 0,2L forward of amidships is not to be less than 150D mm. but need not exceed 2135 mm. and the thickness is not to be less than that of the deck plating or side shell, whichever is the greater.

At ends the thickness of sheerstrake may be the same as the side shell.

4310 The thickness of the sheerstrake is to be increased 20 per cent at the ends of the bridge, but this increase is not required if the bridge does not extend to the ship's side.

If the poop front at side extends within 0,25L from amidships the sheerstrake at the break is to be increased by 20 per cent. No increase is required if the poop front at side is 0,3L from amidships or greater. The increase at intermediate positions is to be obtained by interpolation and is to be applied to the tapered thickness of the sheerstrake.

4311 The upper edge of the sheerstrake is to be dressed smooth and kept free of isolated welded fittings or connections. In ships over 150 metres in length scupper openings are not to be cut above the deck within 0,5L amidships or in way of breaks of superstructures.

Where a rounded sheerstrake is adopted, the welding of fairleads or other fittings to this plate is to be reduced to a minimum and details are to be submitted for approval.

Openings in Shell

4312 Sea inlets in pump rooms situated within 0,5L amidships, are, if practicable, to be fitted clear of the bilge radius. All openings are to be arranged so as to minimise discontinuity of transverse frames, longitudinals or bilge keels. Compensation is to be provided for all openings within 0,5L amidships and may be required for openings in the vicinity of the poop front. The compensation should, if possible, take the form of an insert plate rather than a doubler.

If openings are not circular or oval the corners are to be rounded with as large a radius as practicable.

Bilge Keels

4313 Where bilge keels are fitted, it is desirable that they be attached to a continuous flat bar which may be welded to the shell. Scallops are to be arranged in way of welded butts in the flat bar. Alternative arrangements, or arrangements omitting the flat bar, will be specially considered.

Bilge keels are to be gradually tapered at their ends and are not to finish on an unstiffened panel.

Section 44

BOTTOM, SIDE AND DECK LONGITUDINALS

Scantlings

4401 The scantlings of longitudinals within the range of cargo tanks are not to be less than required by the following formulæ:—

Bottom longitudinals $\frac{I}{y} = \frac{s \times S^2 \times D}{65,85}$ cm.^{3}

Deck longitudinals $\frac{I}{y} = \frac{s \times S^2}{100}\left\{1,85 + \left(\frac{L}{109,7}\right)^3\right\}$ cm.^{3}

Side longitudinals $\frac{I}{y} = \frac{s \times S^2}{118}\left(h + \frac{D}{6}\right)$ cm.^{3}

Where s = spacing of longitudinals in mm.
S = span in metres measured between transverses or from transverse to "span point" (minimum value 2,44 metres),
L = length of ship in metres,
h = distance of longitudinal below deck at side in metres,
D = moulded depth in metres.

The section modulus given by these formulæ is that of the longitudinal and associated plating. (*See* D 5301.)

The scantlings derived from the above, using the midship thickness of plating, are to extend throughout the cargo tanks.

4402 The scantlings of bilge longitudinals are to be graduated between those required for the bottom and lowest side longitudinals.

4403 Where flat bars are used for longitudinals and these are continuous at bulkheads, the thickness is not to be less than one-eighteenth of the depth; otherwise the thickness should not be less than one-fifteenth of the depth.

Connections

4404 End connections of longitudinals to bulkheads are to provide adequate fixity and, so far as practicable, direct continuity of longitudinal strength.

4405 Where the length exceeds 213,5 metres it is desirable that the bottom and deck longitudinals be continuous through the transverse bulkheads but alternative arrangements will be specially considered.

4406 Longitudinals are to be connected to the transverses as required by Table 63E. In ships above 198 metres all longitudinals (including those on longitudinal bulkheads) are to have the web attached to the transverses. In ships between 152,5 and 198 metres, similar arrangements are to be made except that side longitudinals and longitudinal bulkhead horizontal stiffeners need not have the webs attached unless they are within 3 metres of the bottom or deck.

Section 45

TRANSVERSE SIDE FRAMING

Scantlings

4501 Where, in tankers not exceeding 198 metres in length, transverse side framing is adopted in the cargo tanks, the section modulus of side frames is not to be less than:—

$\frac{I}{y} = \frac{s \times h \times S^2}{97,5}$ cm.^{3} where side transverses are fitted,

or $\frac{I}{y} = \frac{s \times h \times S^2}{83,3}$ cm.^{3} where side transverses are not fitted,

where s = frame spacing in mm.,

h = head in metres from mid-point of span to deck at side measured at mid-length of tank,

S = span in metres measured between stringers or from stringer to "span point".

The size of the frame is to be governed by the maximum modulus derived from the above formula and is to be maintained for the full depth of the ship. The modulus given is that of the frame and associated side shell plating. (*See* D 5301.)

Side Stringers

4502 Where the depth D does not exceed 7,6 metres, one side stringer is to be fitted. Where D exceeds 7,6 metres but does not exceed 10,7 metres, 2 stringers are required and over 10,7 metres depth, 3 stringers. For scantlings of stringers *see* D 4702.

Side Transverses

4503 Where the depth D exceeds 10,7 metres, or the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 15,25 metres, side transverses are to be fitted in line with the bottom transverses. The scantlings of the side transverses are to be determined in accordance with D 4608 and D4609.

Connections and End Attachments

4504 Side frames are to be connected to the side stringers as required by Table 63E.

4505 The brackets at the upper end of side frames are to be as shown in Table 63F.

4506 Side frames are to be efficiently connected at the lower end to stiffened brackets covering the entire round of bilge and extending at least to the first bottom longitudinal. The thickness of the bracket is to be the same as that of the transverses in the wing tank.

Section 46

BOTTOM, SIDE AND DECK TRANSVERSES

General

4601 The spacing of transverses is generally not to exceed 3,66 metres when the length L is 183 metres or less or $\frac{L}{50}$ when L exceeds 183 metres. Where, however, the longitudinal bulkhead is corrugated, the spacing of transverses is generally not to exceed 4,27 metres.

Bottom Transverses

4602 The section modulus of the transverses is not to be less than:—

$\frac{I}{y} = 96,45\ s \times D\ (S-1,524)$cm.^{3} where the span does not exceed 10 metres,

or $\frac{I}{y} = 8,15 \times s \times D \times S^2$ cm.^{3} where the span exceeds 10 metres,

where s = spacing of transverses, in metres,

S = span of transverses in metres from "span point" to "span point" (minimum value 2,75 metres),

D = moulded depth, in metres.

Where the bottom centre line girder is intercostal between the transverses the modulus derived as above is to be increased by 10 per cent.

4603 If intercostal side girders are fitted, and their scantlings are in accordance with D 4814, the modulus of the bottom transverses derived in accordance with either of the preceding formulæ may be reduced by 5 per cent.

4604 Where the breadth of centre tank exceeds that given in D 4006, the modulus of the bottom transverses in the centre tank determined from 4602 is to be increased. The increase is to be 20 per cent for a tank breadth equal to that given in D 4005. No increase is required for a tank breadth equal to that given in D 4006 with increases for intermediate breadths of tank by interpolation. Where more than one side girder is fitted, the span to be used in 4602 is not to be less than $\frac{b}{6}$, where b is the breadth of centre tank.

4605 Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, the section modulus of the bottom transverse at about the mid-distance is to be increased, above that determined by 4602, at the rate of 25 per cent for each 1 per cent of the length L by which the distance exceeds 0,07L or 15,25 metres. This increased section modulus is only to be applied when it exceeds that required by 4604.

4606 The depth of the bottom transverse is not to be less than either one-fifth of its span or $2\frac{1}{2}$ times the depth of the slot for the bottom longitudinal, whichever is the greater.

4607 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

Side Transverses

4608 The section modulus of side transverses not supported by cross ties is not to be less than:—

$\frac{I}{y} = 148{,}4\ s \times h\ (S-1{,}524)$ cm.^{3} where the span does not exceed 10 metres,

or $\frac{I}{y} = 12{,}65\ s \times h \times S^2$ cm.^{3} where the span exceeds 10 metres.

Side tranverses supported by cross ties are to have a section modulus not less than that given by the following formulæ:—

Number of Cross Ties	Section Modulus Cm.^{3}
1	$72{,}35\ s\ [(D-7{,}315)^2+7{,}25]$
2	$57{,}8\ s\ [(D-7{,}315)^2+7{,}25]$
3	$48{,}2\ s\ [(D-7{,}315)^2+7{,}25]$
4	$42{,}8\ s\ [(D-7{,}315)^2+7{,}25]$
1 horizontal and 2 diagonal meeting at side transverse	$64{,}3\ s\ [(D-7{,}315)^2+7{,}25]$

In the above

s = spacing of transverse in metres,

h = head from mid-point of span to deck at side, in metres,

S = span of transverse in metres from "span point" to "span point",

D = moulded depth in metres.

4609 Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, the section modulus of the side transverse at about mid-distance is to be increased at the rate of 25 per cent for each 1 per cent of the length L by which the distance exceeds 0,07L or 15,25 metres.

4610 If side transverses are tapered, the increase in depth at the bottom, and decrease at the top, is not to exceed 10 per cent of the mean depth.

4611 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

Deck Transverses

4612 The section modulus of deck transverses is not to be less than that given by the formula

$\frac{I}{y} = 53{,}75\ (0{,}0269\ s \times L+0{,}8)\ (S+1{,}83)$ cm.^{3}

where s = spacing of transverses in metres,

L = length of ship in metres,

S = span of transverse in metres from "span point" to "span point".

4613 If intercostal side girders are fitted, and their scantlings are in accordance with D 4824, the modulus of the deck transverses derived in accordance with the above formula may be reduced by 5 per cent.

4614 Where the breadth of centre tank exceeds that given in D 4006, the modulus of the deck transverses in the centre tank determined from 4612 is to be increased. The increase is to be 20 per cent for a tank breadth equal to that given in D 4005. No increase is required for a tank breadth equal to that given in D 4006 with increases for intermediate breadths of tank by interpolation. Where more than one side girder is fitted the span to be used in 4612 is not to be less than $\frac{b}{6}$, where b is the breadth of centre tank.

4615 Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, the section modulus of the deck transverse at about mid-distance is to be increased, above that determined by 4612, at the rate of 25 per cent for each 1 per cent of the length L by which the distance exceeds 0,07L or 15,25 metres. This increased section modulus is only to be applied when it exceeds that required by 4614.

4616 The depth of the deck transverse is not to be less than one sixth of its span or $2\frac{1}{2}$ times the depth of the slot for the deck longitudinal, whichever is the greater.

4617 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of deck plating *see* D 5305.

Section 47

SIDE STRINGERS

General

4701 Where transverse side framing is adopted, side stringers are to be fitted as required by D 4502.

Scantlings

4702 The modulus of side stringers is not to be less than given by the following formulæ:—

Position of Stringer	Section Modulus Cm.^{3}
Single	$13{,}55\ b \times h \times S^2$
Upper of two or more	$17{,}25\ b \times h \times S^2$
Middle or lower	$13{,}55\ b \times h \times S^2$

where b = width of plating supported, in metres. Where applicable, the width supported is to be taken as half the distance from the next stringer to the deck at side or base line as appropriate.

h = head from stringer to highest point of tank, excluding hatchway, in metres,

S = span from "span point" to "span point" or from "span point" to side transverse, in metres (minimum value to be taken as 3 metres).

4703 The depth of the stringer is not to be less than $2\frac{1}{2}$ times the depth of the slot for the frame.

4704 Where side transverses are not fitted the lower side stringers are to be supported by suitable buttress brackets from the bottom transverses.

4705 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

Section 48

BOTTOM AND DECK GIRDERS

4801 Where the length L exceeds 167,5 metres and a centreline bulkhead is not fitted, the bottom transverses are to be supported by a centreline girder continuous between transverse bulkheads.

Where the length L does not exceed 167, 5 metres the centreline girder may be continuous between transverse bulkheads or may be intercostal between transverses and effectively connected to the transverses and bulkheads.

4802 Side girders are generally to be arranged in the centre and wing tanks in ships exceeding 213,5 metres or where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 16,75 metres. The girders are to be arranged in line with vertical webs on the transverse bulkheads to form a ring system. These girders may be continuous or intercostal except where required by D 4006 or D 4007 to be continuous.

For the purpose of this section continuous girders are those based upon a span between transverse bulkheads.

Continuous Bottom Centreline Girder

4803 The section modulus of the girder is not to be less than:—

$$\frac{I}{y} = 92,6\ b\ D\ (S-0,61)\ cm.^3$$

where the span does not exceed 12,2 metres,

or $$\frac{I}{y} = 7,2\ b \times D \times S^2\ cm.^3$$

where the span exceeds 12,2 metres,

where b = half breadth of centre tank, in metres, or, where there is a vertical web on the inboard side of the longitudinal bulkheads, half the distance between the faces of the webs,

D = moulded depth, in metres,

S = distance, in metres, from "span point" to "span point".

Where continuous side girders having scantlings determined from 4811 are fitted b is to be taken as the distance from the centre girder to the adjacent side girder.

4804 Where intercostal side girders, having scantlings as required by 4814, are fitted in the centre tank, the section modulus of the centre girder derived in accordance with 4803 may be reduced by 5 per cent.

4805 Where the centreline girder is required to be increased for breadth of centre tank (*see* D 4007) the increase in section modulus is to be 20 per cent for a tank breadth equal to or greater than that given in D 4006. No increase is required for a tank breadth equal to $\frac{B}{3}$ with increases for intermediate breadths of tank by interpolation.

Intercostal Bottom Centreline Girder

4806 The section modulus of the girder is not to be less than:—

$$\frac{I}{y} = 14,5\ B \times D \times s\ cm.^3,$$

where B = moulded breadth, in metres,

D = moulded depth, in metres,

s = spacing of transverses, in metres.

4807 The depth of an intercostal girder is not to exceed the depth of the transverses.

Continuous or Intercostal Bottom Centreline Girders

4808 Vertical webs are generally to be arranged on the transverse bulkheads in association with bottom centreline girders.

4809 Flanged or otherwise stiffened brackets are to be fitted on both sides of the girder mid-way between the transverses with intermediate vertical stiffeners not more than 990 mm. apart. The brackets are to be connected to a

suitable bottom longitudinal. In deep centreline girders horizontal stiffening is to be arranged and the brackets on one side may stop at a suitable horizontal stiffener. The intermediate vertical stiffeners may be omitted but where the spacing of brackets exceeds 1830 mm. an intermediate vertical stiffener is to be fitted to the lower part of the girder, or suitable horizontal stiffening is to be arranged.

4810 The thickness of the centre girder is not to be less than 10 per cent thicker than that given in D 5309 unless suitable horizontal stiffening is arranged.

Continuous Bottom Side Girders

4811 The required section modulus of continuous side girders is to be determined from 4803 with b taken as the half breadth of centre tank (or breadth of wing tank measured between faces of the vertical transverses) divided by the number of side girders plus one. (The number of side girders is to be that in the half breadth of centre tank or breadth of wing tank as appropriate).

4812 Where the side girders in the centre tank are required to be increased for breadth of centre tank (*see* D 4006) the increase in section modulus is to be 20 per cent for a tank breadth equal to that given in D 4005. No increase is required for a tank breadth equal to that given in D 4006 with increases for intermediate breadths of tank by interpolation.

4813 Where the breadth of the centre tank is less than $\frac{B}{3}$ the scantlings and arrangements of side girders in the wing tanks will be specially considered.

Intercostal Bottom Side Girders

4814 The section modulus is not to be less than:—

$$\frac{I}{y} = 19\ S^2 \times b_1 \times D\ \text{cm.}^3,$$

where S = span measured from transverse to transverse, in metres,

b_1 = half breadth of centre tank, in metres (or breadth of wing tank) divided by the number of side girders plus one. (The number of side girders is to be that in the half breadth of centre tank or breadth of wing tank as appropriate),

D = moulded depth, in metres.

4815 Where the side girders in the wing tanks are intercostal and are required to be increased for breadth of centre tank (*see* D 4006) the increase is to be as given in 4812.

4816 The depth of the side girder is not to be less than 50 per cent of the depth of the bottom transverse and is to be efficiently bracketed thereto.

General

4817 For reduction to modulus of centre girder and bottom transverses when side girders are fitted in accordance with 4814, *see* 4804 and D 4603.

Deck Centreline Girder

4818 A continuous deck centreline girder is to be fitted having a section modulus not less than:—

$$\frac{I}{y} = \frac{l^2 \times b \times L}{10{,}5}\ \text{cm.}^3$$

where l = length of centre tank, in metres,

b = half-breadth of centre tank, in metres, or, where there is a vertical web on the inboard side of the longitudinal bulkheads, half the distance between the faces of the webs,

L = length of ship, in metres.

Where continuous side girders having scantlings determined from 4821 are fitted b is to be taken as the distance from the centre girder to the adjacent side girder.

4819 Where intercostal side girders, having scantlings as required by 4824, are fitted in the centre tank the section modulus of the deck centre girder derived in accordance with 4818 may be reduced by 5 per cent.

4820 Where the centre line girder is required to be increased for breadth of centre tank (*see* D 4007) the increase is to be as given in 4805.

Continuous Deck Side Girders

4821 The required section modulus of continuous side girders is to be determined from 4818 except that b is to be taken as in 4811.

4822 Where the breadth of the centre tank is less than $\frac{B}{3}$ the scantlings and arrangements of side girders in the wing tanks will be specially considered.

4823 Where the side girders in the centre tank are required to be increased for breadth of centre tank (*see* D 4006) the increase is to be as given in 4812.

Intercostal Deck Side Girders

4824 Intercostal side girders are to have a depth not less than 50 per cent of the depth of the deck transverse. The face area is not to be less than that of the transverses.

4825 Where the side girders in the wing tanks are intercostal and are required to be increased for breadth of centre tank (*see* D 4006) they are to have the same depth and area of face plate as the transverse.

General

4826 For reduction to modulus of deck centre girder and deck transverses when side girders are fitted, *see* 4819 and D 4613.

4827 For minimum thicknesses, *see* D 5308 and D 5309.

For moduli of girders of various depths, face areas and thicknesses of shell or deck plating, *see* D 5305.

Section 49

CROSS TIES

4901 Cross ties may be of plate or sectional material and are to have an area and least moment of inertia not less than:—

$$A = 64+1{,}035\ l \times h \times s \text{ cm.}^2,$$

$$I = 2{,}45\ l \times h \times s \times S^2 \text{ cm.}^4,$$

where l = one half the distance in metres between the centre of the adjacent cross ties or between the centre of the adjacent cross tie and the centre of the bottom or deck transverse,

h = vertical distance in metres from the centre of the cross tie to deck at side amidships,

s = spacing of transverses, in metres,

S = length of cross tie in metres between the toes of the horizontal tripping brackets on the transverse webs at the cross ties. Special consideration will be given where alternative arrangements omitting the tripping brackets are provided.

Diagonal cross ties will be specially considered but, in general, the area and least moment of inertia of the horizontal cross tie is not to be less than 85 per cent of that required by the above formula assuming the centre cross tie only is fitted. The area of each diagonal cross tie is not to be less than 85 per cent of that required for the horizontal cross tie.

4902 Cross ties are to be connected to the vertical transverses or horizontal girders by suitable brackets. Tripping brackets are to be fitted to the transverses in way of the cross ties and where scallops for longitudinals or frames come in way of the cross ties they are to be closed by plate collars.

4903 Cross ties are to be provided with suitable horizontal stiffening to prevent buckling and twisting. Where the unsupported width of face plate exceeds 150 mm., additional vertical stiffening is to be arranged to support the face plate.

Section 50

OILTIGHT AND NON-OILTIGHT BULKHEADS

OILTIGHT BULKHEADS

General

5001 Longitudinal bulkheads, other than at the centre line, are to be oiltight throughout the cargo tanks and may be plane or horizontally corrugated.

Where a centre line bulkhead is required by D 4005 it may be oiltight or perforated.

Longitudinal bulkheads may be perforated in pump rooms or cofferdams, provided suitable compensation is arranged.

When a wash bulkhead is fitted, the length or breadth of a tank may, for the purposes of 5015 and 5029, be measured from the wash bulkhead to the oiltight bulkhead.

5002 Where the ship's side is framed longitudinally the stiffening on the longitudinal bulkheads is to be arranged horizontally. Vertical stiffening may be adopted in association with transverse side framing.

5003 Transverse bulkheads may be plane or with corrugations arranged horizontally or vertically.

5004 The scantlings of cofferdam bulkheads not forming the boundary of a cargo tank are to be as required by D 20 for oil fuel deep tanks.

Where a pump room acts as a cofferdam, a bulkhead which does not form part of the boundary of a cargo tank or an oil fuel bunker may be of watertight bulkhead scantlings in accordance with D 16 except that, in a riveted bulkhead, the riveting is to be as required for an oiltight bulkhead.

5005 Beyond the ends of the oil tanks the longitudinal bulkheads are to scarph into the adjoining structure.

PLANE BULKHEADS

Plating

5006 The thickness of the plating is not to be less than

$$t = \left(0{,}31+\frac{h}{61}\right)\frac{s}{30} \text{ mm.},$$

except that the thickness of the top and bottom strakes of longitudinal bulkheads is in no case to be less than:—

$$\text{Top strake} \qquad t = \left(0{,}22+\frac{L}{610}\right)\frac{s}{30} \text{ mm.},$$

$$\text{Bottom strake } t = \left(0{,}28+\frac{L}{610}\right)\frac{s}{30} \text{ mm.,}$$

where h = distance, in metres, from lower edge of plate to highest point of tank, excluding the hatchway,

s = spacing of stiffeners, in mm.,

L = length of ship, in metres.

The breadth of the top and bottom strakes of longitudinal bulkheads is not to be less than 100D mm.

For minimum thickness *see* D 5308.

Stiffeners

5007 The section modulus of horizontal or vertical stiffeners is not to be less than:—

$$\frac{l}{y} = \frac{s\,S^2}{117{,}5}\,(h + 0{,}9) \text{ cm.}^3$$

where s = spacing in mm.,

S = span in metres measured between girders or from girder to "span point",

h = distance in metres from centre of span to highest point of tank, excluding the hatchway.

The section modulus given by this formula is that of the stiffener and associated plating. (*See* D 5301.)

5008 The modulus of horizontal stiffeners on longitudinal bulkheads is not to be less than 90 per cent of the modulus of the uppermost side longitudinal.

5009 The modulus of vertical stiffeners on longitudinal or transverse bulkheads may be reduced by 10 per cent where vertical webs are fitted.

5010 Stiffeners are to be bracketed or otherwise efficiently connected at their ends to provide adequate fixity and, for horizontal stiffeners, continuity of longitudinal strength at the bulkheads.

The end brackets of longitudinal bulkhead vertical stiffeners are to be as required by Table 63F and are to be connected to a suitable longitudinal or are to be well hollowed and tapered.

All stiffeners are to be connected to the supporting webs or girders as required by Table 63E.

The plating is to be efficiently stiffened to support loads transmitted by end connections of longitudinal bulkhead, shell and deck longitudinals and the like.

Webs and Girders

5011 The section modulus of vertical webs and horizontal girders is not to be less than that required by the appropriate formula below:—

Item	Section Modulus cm.^{3}
1. Vertical Webs (other than in (2) below)	
(a) On transverse bulkheads not forming a ring system but including the web on the centre line.	$12{,}65\,b \times h \times S^2$
(b) On transverse bulkheads forming a ring system* (other than at centre line) as primary supporting members and supporting horizontal stiffeners.	$10\,b \times h \times S^2$
(c) On longitudinal bulkheads	90 per cent of side transverse
2. Intercostal Vertical Webs on Transverse Bulkheads not Supporting Stiffeners	$6{,}9\,b_1 \times h \times S^2$
3. Horizontal Girders on Longitudinal or Transverse Bulkheads	
(a) Single girder	$11{,}9\,b \times h \times S^2$
(b) Upper of two or more	$14{,}6\,b \times h \times S^2$
(c) Middle or lower	$11{,}9\,b \times h \times S^2$

* i.e., in association with bottom and deck girders of Rule scantlings.

(*See also* 5012 to 5015).

In the above:—

b = width of plating supported, in metres,

h = distance in metres from centre of span to highest point of tank, excluding hatchway,

S = span in metres from "span point" to "span point".

For horizontal girders on longitudinal bulkheads a minimum value of 3 metres is to be used.

For intercostal vertical webs not supporting stiffeners (item 2 in above Table) b_1 is to be taken as half the breadth of centre tank (or the breadth of wing tank) in metres divided by the number of webs plus one (number of webs to be those in the half breadth of centre tank or breadth of wing tank as appropriate) and S is to be measured between girders or from girder to span point. The maximum value of $6{,}9\,b_1 \times h \times S^2$ is to be used for the full depth of bulkhead.

5012 Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, the section modulus

of the vertical web on the longitudinal bulkhead at about the mid-distance is to be the same as that of the increased side transverse. Where the distance between bulkheads is 0,085L or greater, the vertical web is to be symmetrical on both sides of the longitudinal bulkhead to give a section modulus not less than that of the increased side transverse.

5013 Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 16,75 metres the centre line vertical web is to be symmetrical on both sides of the transverse bulkhead.

5014 Where webs are symmetrical on each side of a plane bulkhead the section modulus derived as above may be reduced by 10 per cent except where the vertical web on the longitudinal bulkhead is required to be symmetrical to comply with 5012.

5015 Where the breadth of a cargo tank exceeds 13,5 metres the section modulus of the vertical webs and horizontal girders on the longitudinal bulkhead is to be increased at the rate of 2 per cent per 0,3 metre excess above 13,7 metres, but the modulus of the vertical web need not exceed that required for the side transverse. (*See also* 5001).

5016 Where side transverses are required by D 4503, vertical webs are to be fitted on the longitudinal bulkhead. Where vertical webs are not fitted, the lower horizontal girders are to be supported by suitable buttress brackets from the bottom transverses.

5017 The depth of a girder or web is not to be less than $2\frac{1}{2}$ times the depth of the slot for the stiffener.

For minimum thicknesses *see* D 5308 and D 5309.

For moduli of webs and girders of various depths, face areas and bulkhead plating *see* D 5305.

5018 The end attachments of vertical webs and horizontal girders are to have a length of arm at least equal to the depth of web.

CORRUGATED BULKHEADS

General

5019 Where corrugated bulkheads are adopted the corrugations should be arranged in accordance with 5001 and 5003.

5020 In ships above 183 metres in length the upper and lower strakes of the longitudinal bulkhead are to be plane for a distance of 100D mm. from the deck and bottom and the vertical webs are to be arranged symmetrically on each side of the longitudinal bulkhead. Alternative arrangements with unsymmetrical webs will be specially considered, having in view the spacing of transverses and the type of transverse bulkhead, etc.

Plating

5021 The thickness of the plating is not to be less than

$$t = \left(0{,}31 + \frac{h}{61}\right)\frac{s}{30}\text{ mm.}$$

where h = distance, in metres, from lower edge of plate to highest point of tank, excluding hatchway,

s = width of panel, in mm. (flat or inclined surface, i.e., b or c in the figure in 5022, whichever is the greater). A minimum value of 610 is to be used in this formula.

When s exceeds 840 mm. the scantlings will be specially considered.

The thickness of the top and bottom strakes of longitudinal bulkheads is to be not less than required by 5006.

The thickness of plating is also to be such that the requirements of 5022 are satisfied.

For minimum thickness *see* D 5308.

5022 The minimum angle of corrugation is to be 40° and the dimensions of the corrugations are to fulfil the following conditions:—

(1) $\dfrac{t\ d\ (3\ b+c)}{59\ p}$ not to be less than $h\ S^2$

(2) $\dfrac{t\ d^2\ (3\ b+c)}{6030\ p}$ not to be less than $h\ S^3$

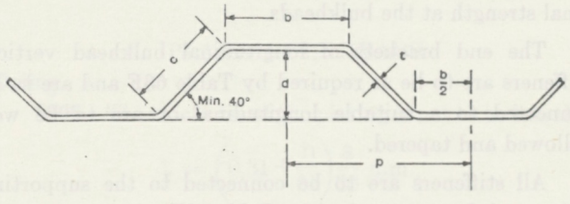
except that when a vertically corrugated transverse bulkhead is supported by two or more horizontal girders 4520p may be substituted for 6030p in (2) for the portion between the girders.

In the above:—

h = distance, in metres, from centre of span to highest point of tank, excluding hatchway,

S = span of corrugation, in metres, measured from girder to girder, transverse to transverse or side, bottom, deck or bulkhead to transverse or girder,

and t, b, c, d and p in mm. are as shown in the sketch below.



In (1) and (2) above the value of b is not to be taken as greater than 50 t. Where unsymmetrical girders or webs are fitted to corrugated bulkheads, the maximum angle of corrugation is to be 60°.

5023 Corrugations are to be in line, and of the same form, on each side of bulkheads, horizontal girders and vertical webs.

Webs and Girders

5024 Horizontal girders and vertical webs are to be arranged to support the corrugations so that the span of the corrugated bulkhead does not exceed 4,88 metres, except that the top span of a vertically corrugated bulkhead may be 5,2 metres. (For vertical webs on longitudinal bulkheads *see also* D 4601.)

5025 The section modulus of vertical webs and horizontal girders is not to be less than that required by the appropriate formula below:—

Item	Section Modulus cm.³
1. Vertical Webs	
(a) On Vertically Corrugated Bulkheads	
At centreline	$12{,}65b \times h \times S^2$
Other webs forming a ring system* and not supporting girders	$6{,}9b_1 \times h \times S^2$
(b) On Horizontally Corrugated Bulkheads	
(i) Tranverse bulkheads:	
At centre line	$12{,}65b \times h \times S^2$
Other webs forming a ring system*	$10b \times h \times S^2$
Webs not forming a ring system	$12{,}65b \times h \times S^2$
(ii) Longitudinal bulkheads	90 per cent of side tranverse
2. Horizontal Girders on Vertically Corrugated Transverse Bulkheads	
(a) Single girder	$11{,}9b \times h \times S^2$
(b) Upper of two or more	$14{,}6b \times h \times S^2$
(c) Middle or lower	$11{,}9b \times h \times S^2$

* i.e., in association with bottom and deck girders of Rule scantlings.

(*See also* 5026 to 5029)

In the above:—

b = width of plating supported, in metres,

h = distance in metres from centre of span to highest point of tank, excluding hatchway,

S = span in metres from "span point" to "span point".

For vertical webs forming a ring system and not supporting girders, b_1 is to be taken as half the breadth of the centre tank (or breadth of wing tank) in metres divided by the number of webs plus one and S is to be measured between girders or from girder to span point. The maximum value of $6{,}9\ b_1 \times h \times S^2$ is to be used for the full depth of bulkhead.

5026 Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds $0{,}07L$ or 15,25 metres, whichever is the greater, the section modulus of the vertical web on the longitudinal bulkhead at about the mid-distance is to be the same as that of the increased side transverses.

Where the web is symmetrical on both sides of the bulkhead, the modulus may be reduced by 10 per cent provided the distance between bulkheads is less than $0{,}085L$.

Where the distance between bulkheads is $0{,}085L$ or greater, the vertical web is to be symmetrical on both sides of the longitudinal bulkhead, to give a section modulus not less than that of the increased side transverse.

5027 Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 16,75 metres the centreline vertical web is to be symmetrical on both sides of the transverse bulkhead.

5028 Where webs or girders are symmetrical on each side of a corrugated bulkhead the section modulus derived as above may be reduced by 10 per cent except where the vertical web on the longitudinal bulkhead is required to be symmetrical to comply with 5026.

5029 Where the breadth of a cargo tank exceeds 13,5 metres the section modulus of the vertical webs on the longitudinal bulkhead is to be increased at the rate of 2 per cent per 0,3 metre excess above 13,5 metres. (*See also* 5001.)

5030 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of webs and girders of various depths, face areas and bulkhead plating *see* D 5305.

5031 The end attachments of vertical webs and horizontal girders are to have a length of arm at least equal to the depth of web.

NON-OILTIGHT BULKHEADS (PLANE OR CORRUGATED)

General

5032 Wash bulkheads and perforated centreline longitudinal bulkheads are to have an area of perforations not less than 10 per cent of the total area of the bulkhead. The perforations are to be so arranged that the bulkheads act as an efficient girder, web or transverse and the lower part of a centreline bulkhead is to be adequately stiffened to act as a docking girder.

Special care is to be taken to ensure that a perforated centreline longitudinal bulkhead provides an efficient connection between the deck and bottom plating.

Plating

5033 The thickness of plating may be the compartment minimum (*see* D 5308) except that the top and bottom strakes of a centreline bulkhead are to be as required by 5006 for an oiltight longitudinal bulkhead.

Stiffeners, Girders and Webs

5034 The section modulus of stiffeners and horizontal girders is to be not less than:—

$$\frac{I}{y} = k \times s_1 \times S^2 \times \frac{l}{L} \text{ cm.}^3,$$

where $k = 1215 \times 10^{-4}$ for stiffeners on transverse bulkheads,
3785×10^{-4} for stiffeners on longitudinal bulkheads,
145 for girders on transverse bulkheads,
452 for girders on longitudinal bulkheads,

s_1 = spacing of stiffeners, in mm., or width of plating supported by girder, in metres,

S = maximum span of stiffeners between girders, or from girder to "span point", in metres, or span of girder from "span point" to "span point", in metres,

l = length or breadth, in metres, of tank between oiltight bulkheads for transverse or longitudinal bulkheads respectively. Where two or more transverse wash bulkheads are fitted in one tank l is to be measured between the bulkheads adjacent to the wash bulkhead under consideration,

L = length of ship, in metres.

5035 The section modulus of vertical webs is to be not less than:—

On transverse bulkheads—the modulus required for an oiltight bulkhead multiplied by $\left(0{,}3+2\frac{l}{L}\right)$

where l and L are as defined in 5034.

On longitudinal bulkheads—50 per cent of that required for an oiltight bulkhead.

5036 The depth of webs and girders is to be at least $2\frac{1}{2}$ times the depth of the slot for the stiffener.

5037 When determining the width of plating supported and the effective area for calculating the modulus no deduction is to be made on account of perforations.

Section 51

HATCHWAYS

Oiltight Hatchways

5101 Oiltight hatchways are to be kept to the minimum size required to provide reasonable access and ventilation to each compartment.

Corners of hatchway openings are to be well rounded and smooth.

5102 The height of the coaming is not to be less than 255 mm. Coaming plates not exceeding 815 mm. in height are not to be less than 10 mm. in thickness.

5103 Where the area of the hatchway cover does not exceed 1,12 square metres in a circular hatchway, or 1,49 square metres in a rectangular hatchway, the thickness of the cover is to be 12,5 mm.

If the area exceeds the above but does not exceed 2,32 square metres the thickness of the cover is to be 15 mm. or may be 12,5 mm. if stiffened by 100 mm. flats spaced 610 mm. apart.

5104 Covers are to be secured by fastenings spaced not more than 457 mm. apart in a circular hatchway or 380 mm. apart in a rectangular hatchway and not more than 230 mm. from the corners.

Hatchway covers of special design with alternative methods of closing will be specially considered.

Ullage Plugs and Tank Cleaning Openings

5105 Ullage plugs, sighting ports and tank cleaning openings are not to be arranged in enclosed spaces.

Access to Cofferdams, Dry Tanks or Water Ballast Tanks

5106 If hatchways are provided for access to these spaces the requirements of 5101 to 5104 are to be complied with.

5107 Access may be by a watertight manhole provided the plate cover is not less than 12,5 mm. in thickness and the bolts are not more than 100 mm. apart.

Hatchways to Spaces other than Oil Tanks, Cofferdams Dry Tanks, or Water Ballast Tanks

5108 Hatchways are to be constructed in accordance with the requirements of D 23 except that efficient steel watertight covers are to be fitted to hatchways situated on expansion trunks and on the strength deck, either where exposed or inside open superstructures.

Hatchways situated on the forecastle deck are to have steel covers except where efficient steel watertight covers are fitted to the hatchways inside the forecastle.

Section 52

TESTING

General

5201 Each cargo tank and cofferdam is to be separately tested by filling with water to the test head.

When water testing on the building berth or in dry dock may be undesirable, testing may be carried out afloat, provided any riveted shell seams in the bottom and bilge plating are tested with a high pressure hose test on the berth. The testing afloat is to be carried out by separately filling each tank and cofferdam to the test head. With about half the number of tanks full, the bottom and lower side shell in the empty tanks is to be examined and the remainder of the bottom and lower side shell examined when the water is transferred.

When a preservative coating is to be applied to the internal structure of a tank, the water testing may take place after the application of the preservative, provided the structure is carefully examined to ensure that all welding and structural stiffening is completed prior to the application of the coating and any riveted shell seams are tested with a high pressure hose test on the berth before coating. The hose test of the riveted seams may be carried out from the outside to avoid wetting the tank structure.

The cause of any discoloration or disturbance of the coating is to be ascertained and any deficiencies repaired.

5202 In lieu of the complete water testing required by 5201 a combination of a leak test and a structural test may be adopted.

The leak test is to be carried out on each tank while the vessel is on the building berth; it is to consist of a soapy solution test made while the tank is subjected to an air pressure of 0,14 kg. per cm.^{2}. It is recommended that the air pressure in the tank be raised to 0,21 kg. per cm.^{2} with the minimum number of personnel in the vicinity of the tank and lowered to the test pressure before inspection commences.

A structural test is to be applied to one centre and two side tanks (to be selected by the Surveyor) by water testing to the test head (*see* 5205).

Air testing is to be carried out before a protective coating is applied.

5203 Water ballast and dry tanks should be tested as required for cargo tanks.

5204 It is recommended that pump rooms be flooded to a suitable depth prior to launch. The bottom and side shell plating is to be carefully examined internally with the vessel at a deep draught. Bulkheads not forming tank boundaries are to be hose tested.

Test Head

5205 The test head for cargo tanks is to be 2,45 metres above the highest point of the tank, excluding hatchways; that for cofferdams is to be to the top of the hatchway.

Bunkers and Deep Tanks

5206 Bunkers and deep tanks are to be tested as required by D 2031 and D 1914 respectively.

Section 53

EFFECTIVE SECTION MODULUS, FACE AREAS AND MINIMUM THICKNESSES

EFFECTIVE SECTION MODULUS

Longitudinals, Frames and Stiffeners

5301 For longitudinals, side frames and bulkhead stiffeners the section modulus required by the appropriate formula is to be that of the section in association with 610 mm. of plating having the same thickness as the shell, deck or bulkhead plating as appropriate. Where the attached plating is of varying thickness, the mean thickness over the appropriate span is to be used.

The effective section moduli of rolled sections and the area of the section without plating are given in the publication "Geometric Properties of Rolled Sections and Built Girders".

The effective section moduli of flat bars or built sections may be obtained from curves in the above publication.

Transverses, Webs, Stringers and Girders

5302 For transverses, webs, stringers and girders, the section modulus required by the appropriate formula is to be that of the member in association with an effective area of shell, deck or bulkhead plating.

5303 Except for corrugated bulkheads, the effective area is to be:—

$$A = 10\ k\ b\ t_p \text{ square cm.,}$$

where k = a coefficient obtained from the table below,

b = actual width in metres of load-bearing plating, i.e., one half the sum of spacings of parallel adjacent members of greater or equivalent length (*see* sketches on pages 233 and 234),

t_p = mean thickness of attached shell, deck or bulkhead plating in mm.,

l = overall length of girder, transverse, etc., in metres (*see* sketches on pages 233 and 234).

$\frac{l}{b}$	0,5	1,0	2,0	3,0	4,0	5,0	6,0
k	0,12	0,23	0,45	0,67	0,80	0,90	1,00

For intermediate values of $\frac{l}{b}$, k is to be obtained by interpolation. Where $\frac{l}{b}$ exceeds 6,0, k is to be taken as 1,0.

5304 For corrugated bulkheads the effective area is to be:—

(a) for girders, etc., at right angles to the direction of corrugations:

A = area of face plate in square cm. (*see also* 5307.)

(b) for girders, etc., parallel to the direction of corrugations:

$$A = \frac{b_c\, t_p}{100} \text{ square cm.,}$$

where b_c = breadth in mm. of flat panel of corrugated bulkhead,

t_p = thickness of bulkhead plating in mm. Where the bulkhead thickness varies, the mean thickness over the appropriate span is to be used.

5305 The effective section modulus of any transverse, web, stringer or girder is given by the formula:—

$$\frac{I}{y} = \frac{ad}{10} + \frac{t_w\, d^2}{6000}\left[1 + \frac{200\,(A - a)}{200\,A + t_w\, d}\right] \text{ cm.}^3$$

where a = area of face plate in square cm.,

d = depth of girder, etc., between inside of face plate and attached plating, in mm. Where the girder, etc., is at right angles to the line of corrugations the minimum depth is to be taken,

t_w = thickness of web in mm.,

A = effective area of associated plating in square cm. Where the effective area derived in accordance with 5303 or 5304 is less than the face area, A is to be taken as equal to a.

For girders, etc., which are symmetrical on each side of the bulkhead the attached plating is to be ignored and the effective section modulus is given by:—

$$\frac{I}{y} = \frac{ad}{10} + \frac{t_w\, d^2}{6000} \text{ cm.}^3$$

where a = area of one face plate in square cm.,

d = depth of girder between insides of face plates in mm.,

t_w = thickness of web, in mm.

5306 The curves in the publication "Geometric Properties of Rolled Sections and Built Girders" may also be used to determine the effective section modulus.

MAXIMUM AND MINIMUM FACE AREAS

5307 The area of material in the face plate of any transverse, web, stringer or girder is not to exceed $\frac{d\, t_w}{150}$ square cm. where d and t_w are the depth of girder and web thickness as defined in 5305.

The face area is not to be less than:—

(a) bottom centre line girder $\frac{l\, d}{60}$ square cm.,

(b) other transverses, girders, etc., $\frac{l\, d}{240}$ square cm.,

where l = distance between docking or tripping brackets in metres,

d = depth of girder in mm.

MINIMUM THICKNESS

5308 No part of the structure within the range of the cargo tanks is to be less in thickness than:—

$$t_{min} = 6{,}85 + 0{,}024L \text{ mm.,}$$

where L = length of ship.

Where L exceeds 198 metres t_{min} may be taken as 11,5 mm.

This minimum also applies to cofferdams at the ends of, or between, cargo tanks, but, except as indicated below, not to pump rooms.

In pump rooms the above minimum thickness applies to shell, decks, longitudinal bulkheads and to the bottom, side, deck and bulkhead longitudinals.

For other items solely within these spaces the minimum derived from the formula may be reduced by 1 mm.

For permissible reductions when an approved system of corrosion control is fitted, *see* D 4018.

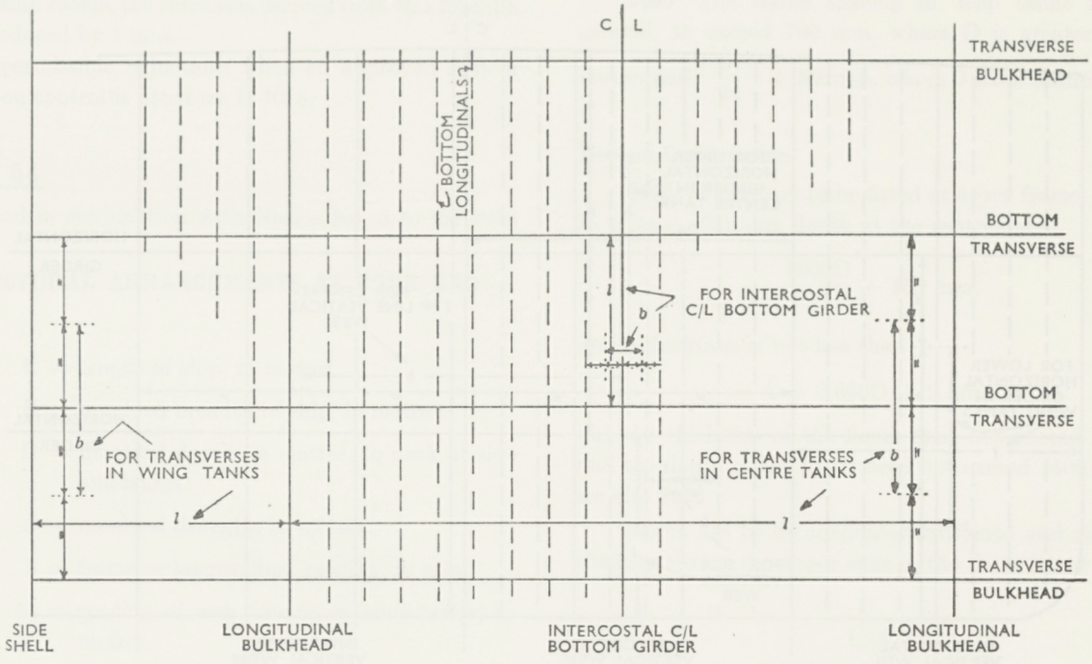
5309 The thickness of the web plate of a transverse, web, stringer or girder is not to be less than the greater of the thicknesses required by 5308 or by the following formula:—

$$t_{min} = 8{,}9 + 0{,}008\left(\frac{d}{100}\right)^2 \text{ mm.,}$$

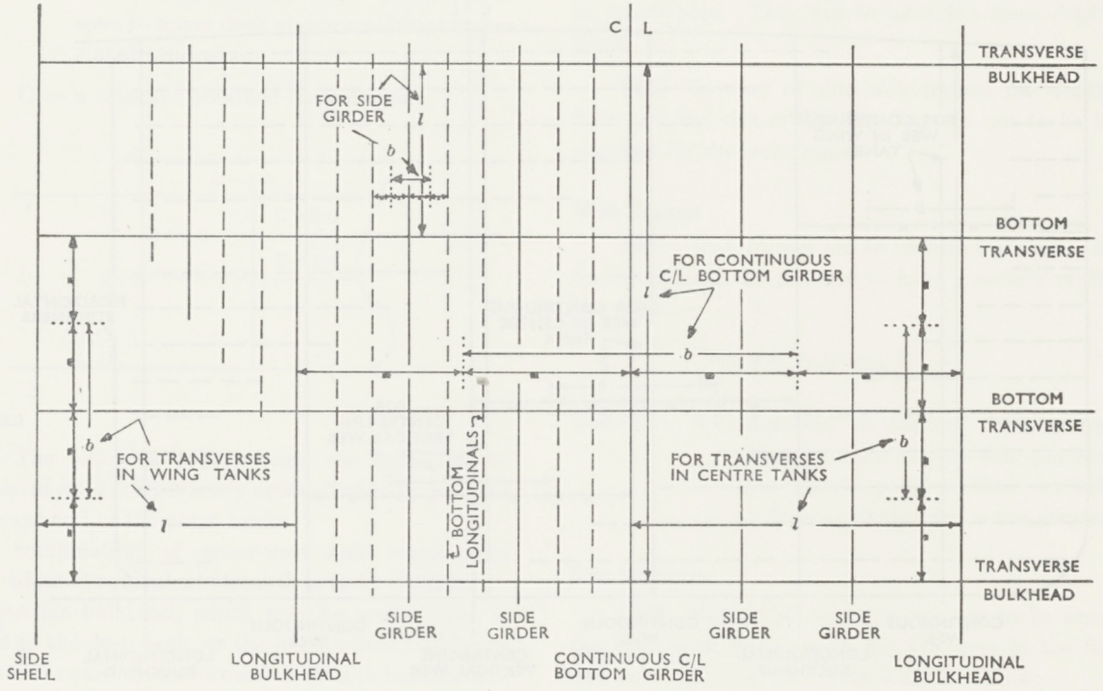
where d = depth of girder in mm. (In a symmetrical girder d may be measured between inside of face plate and the bulkhead plating.)

TO ILLUSTRATE PARAGRAPH D 5303

(a) BOTTOM STRUCTURE WITH INTERCOSTAL BOTTOM CENTRE-LINE GIRDER

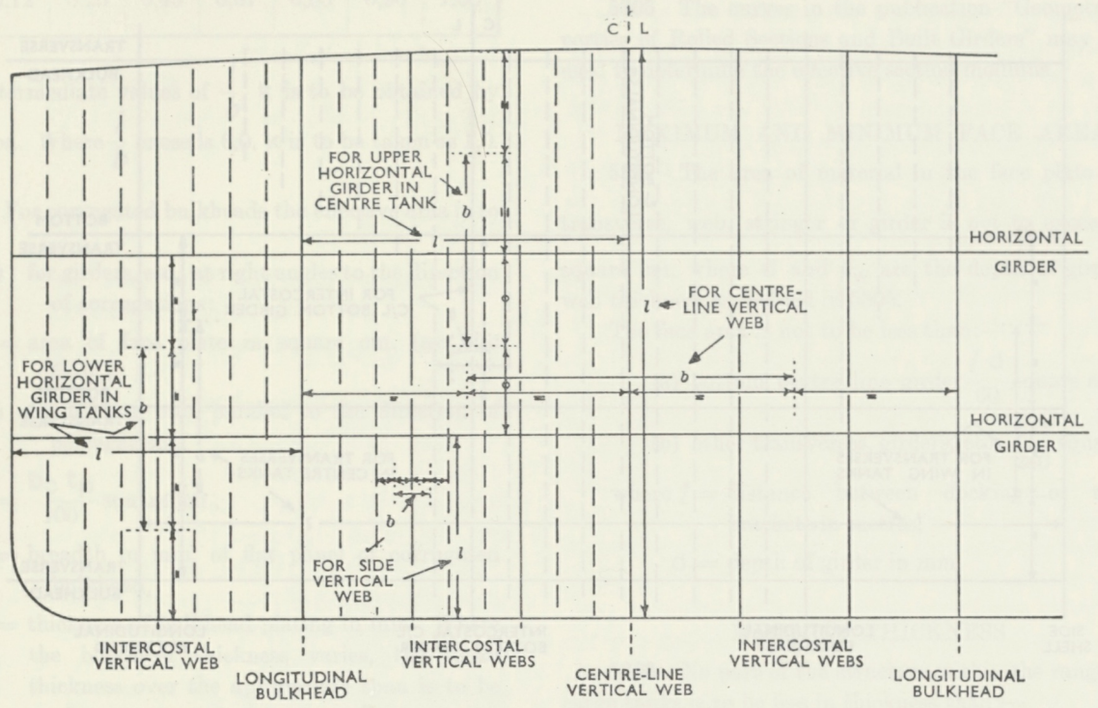


(b) BOTTOM STRUCTURE WITH CONTINUOUS BOTTOM CENTRE-LINE GIRDER

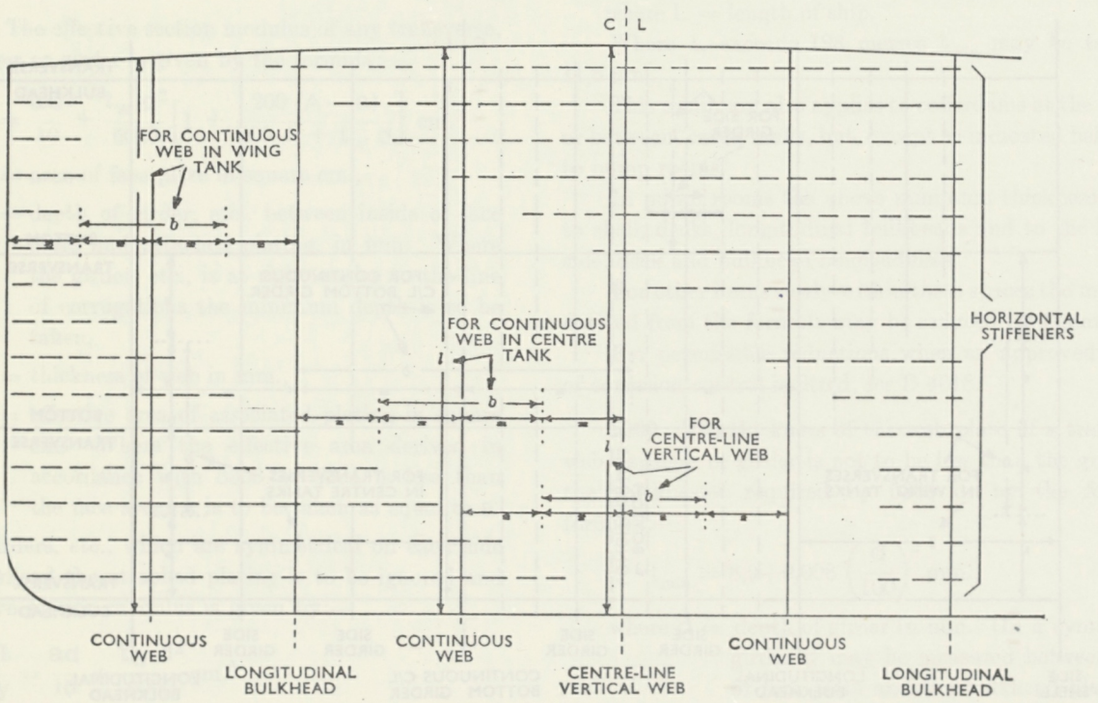


TO ILLUSTRATE PARAGRAPH D 5303

(c) TRANSVERSE BULKHEAD WITH VERTICAL STIFFENING



(d) TRANSVERSE BULKHEAD WITH HORIZONTAL STIFFENING



The web thickness need not exceed 14 mm. except for the bottom centre line girder where the thickness need not exceed 18 mm. if vertically stiffened or 16,5 mm. if horizontally stiffened.

In pump rooms, the thickness derived from this formula may be reduced by 1 mm.

For permissible reductions when an approved system of corrosion control is fitted *see* D 4018.

Section 54

(To be read in conjunction with Notice No. 5 to the 1966 Rules.)

STRUCTURAL ARRANGEMENTS AT FORE END

Symbols

5401 L = length of ship, in metres.

B = moulded breadth of ship, in metres.

D = moulded depth, in metres, to deck at side amidships.

d = moulded draught, in metres.

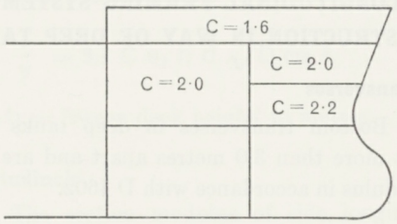
s = frame or longitudinal spacing, in mm.

s_1 = spacing of web frames or transverses, in metres.

S = span, in metres, from span point to span point.

h = distance, in metres, from mid-point of span to upper deck at side amidships unless stated otherwise.

C = a constant obtained from diagram.



Construction

5402 The following requirements are applicable to tankers framed either transversely or longitudinally forward of the forward end of the cargo tanks.

If a combination of transverse and longitudinal framing is adopted equivalent strength is to be provided.

A centreline bulkhead, which may be non-oiltight, is to be fitted in the deep tank, or the longitudinal bulkheads are to extend forward to the forward deep tank bulkhead.

TRANSVERSE FRAMING SYSTEM CONSTRUCTION IN WAY OF DEEP TANKS

Frame Spacing

5403 The frame spacing in deep tanks is not, in general, to exceed 700 mm. where D is greater than 8,9 metres and $\frac{1000D}{24} + 330$ mm. where D is less than 8,9 metres.

Bottom Construction

5404 Floors are to be fitted at every frame. They are to have a minimum depth at the centreline of

$$\frac{1000D}{12} + 150 \text{ mm.}$$

and a thickness of not less than:—

$$t = 0{,}666D + 2 \text{ mm.}$$

but the thickness of the floors need not exceed 11,5 mm. and the depth of the floors need not exceed 1400 mm., but *see also* 5406.

Floors are to be adequately stiffened and the area of the face bar on the upper edge of the floors is not to be less than:— $\frac{B}{1{,}18}$ cm.^{2}

5405 Intercostal side girders are to be fitted between the floors, in line with alternate bottom longitudinals in the forward cargo tanks, and are to be extended as far forward as practicable. They are to have the same depth as the floors.

5406 In way of side web frames the depth of the floor and the size of the face bar are not to be less than required for the web frame.

Web Frames

5407 Web frames are to be fitted not more than five frame spaces apart and are to have a section modulus not less than:—

$$\frac{I}{y} = 9\, s_1\, h\, S^2 \text{ cm.}^3$$

where h = distance, in metres, from mid-point of span to upper deck at side amidships or to the highest point of tank, excluding the hatchway, whichever is the greater.

Side Stringers

5408 Horizontal side stringers are to be arranged in the deep tank in line with the stringers in the fore peak and are to have section moduli not less than:—

(1) supporting stringers which are to be in line with alternate fore peak stringers:—

$$\frac{I}{y} = 33{,}2\ h\ s_1^2\ \text{cm.}^3$$

and (2) intermediate stringers:—

$$\frac{I}{y} = 23{,}3\ h\ s_1^2\ \text{cm.}^3$$

where in both the above:—

h = distance, in metres, from stringer to upper deck at side amidships or to the highest point of tank, excluding the hatchway, whichever is the greater.

Side Framing

5409 Deep tank side frames are to be determined in accordance with D 722 with H measured between the supporting stringers, *see* 5408(1).

Deep Tanks Extending to Uppermost Continuous Deck

5410 For additional requirements when deep tanks extend to the uppermost continuous deck, *see* 5438.

CONSTRUCTION IN DRY CARGO HOLD ABOVE DEEP TANKS

Web Frames

5411 Web frames are to be fitted in the dry cargo hold in line with those in the deep tank below and are to have a section modulus not less than:—

$$\frac{I}{y} = 1{,}68\ C\ s_1\ h_1\ d\ \sqrt{D}\ \text{cm.}^3$$

where h_1 = 'tween deck height, in metres.

Side Stringers

5412 Side stringers are to be fitted in dry cargo holds, spaced about 2,5 metres apart and are to have the same depth as the frame. The minimum thickness of the intercostal plate web is to be 8,5 mm. and the area of the face plate is to be:—

$$\frac{L}{7} + 6\ \text{cm.}^2$$

Framing

5413 Frames in dry cargo holds above deep tanks are to be determined in accordance with D 708 but ignoring the panting factor "f" in D 702.

CONSTRUCTION IN FORE PEAKS

Framing

5414 The frames in the fore peak are generally to be spaced 610 mm. apart and are to be determined in accordance with D 714 and to have a vertical extent not less than required by D 702.

Floors

5415 Floors are to be fitted at every frame, and are to have a depth and thickness not less than required by 5404, and their free edges are to be suitably stiffened.

Panting Beams

5416 Tiers of panting beams are to be fitted on alternate frames in the fore peak, spaced not more than 2,0 metres apart. They are to have scantlings in accordance with D 1103.

5417 If desired, an arrangement incorporating perforated flats in lieu of tiers of panting beams may be adopted. These may be spaced 2,5 metres apart and are to have scantlings required by 5438(1).

Side Stringers

5418 Side stringers determined in accordance with D 1106 are to be fitted at each tier of panting beams.

'Tween Decks Above Fore Peaks

5419 Frames in 'tween decks above fore peaks are to be determined in accordance with D 708.

LONGITUDINAL FRAMING SYSTEM CONSTRUCTION IN WAY OF DEEP TANKS

Bottom Transverses

5420 Bottom transverses in deep tanks are to be spaced not more than 3,0 metres apart and are to have a section modulus in accordance with D 4602.

Bottom Longitudinals

5421 Bottom longitudinals are to be fitted in line with those in the cargo tanks and are to have a section modulus in accordance with D 4401.

Side Girders

5422 An intercostal side girder, which is to have the same depth as the bottom transverses, is to be fitted each side of the centreline.

Centreline Girder

5423 Where the cargo tank longitudinal bulkheads are extended forward into the deep tanks and the centreline bulkhead is omitted, a centre girder having a section modulus in accordance with D 4803 is to be fitted.

Side Transverses

5424 Side transverses are to be spaced not more than 3,0 metres apart and are to have a section modulus not less than:—

$$\frac{I}{y} = 9\ s_1\ h\ S^2\ cm.^3$$

Side transverses are to be in line with forecastle deck transverses.

Side Longitudinals

5425 The section modulus of the side longitudinals is not to be less than:—

$$\frac{I}{y} = \frac{s\ S^2}{132}\left(h + \frac{D}{6}\right)\ cm.^3$$

but h is not to be taken as less than 1,00 metre.

Deep Tank Extending to Uppermost Continuous Deck

5426 For additional requirements when deep tanks extend to the uppermost continuous deck, *see* 5438.

CONSTRUCTION IN DRY CARGO HOLDS ABOVE DEEP TANKS

Side Transverses

5427 Side transverses in the dry cargo hold are to be in line with those in the deep tank below and are to have a section modulus not less than:—

$$\frac{I}{y} = 2{,}1\ C\ s_1\ h\ d\ \sqrt{D}\ cm.^3$$

where h = 'tween deck height, in metres.

Side Longitudinals

5428 The section modulus of side longitudinals in cargo holds above deep tanks is to be in accordance with 5425.

CONSTRUCTION IN FORE PEAKS

Bottom Construction

5429 Floors, which are generally to be spaced 610 mm. apart, are to have a depth and thickness not less than required by 5404 and their free edges are to be suitably stiffened.

Side Transverses

5430 Side transverses are to be spaced not more than 2,5 metres apart and are to have a section modulus not less than:—

$$\frac{I}{y} = 9\ s_1\ h\ S^2\ cm.^3$$

In order to provide adequate end fixity for the side transverses, suitable transverses are to be arranged under the deck or flat in way of the side transverses, and the depth of floor in way is not to be less than that of the side transverse. The face bar of the transverse is to be continuous along the upper edge of the floor.

5431 If perforated flats are fitted to support the side transverses their scantlings are to be in accordance with 5438(1).

Side Longitudinals

5432 Fore peak side longitudinals are to have a section modulus not less than required for peak frames in D 714 and their vertical extent is to be as required by D 702.

'TWEEN DECKS ABOVE FORE PEAKS

Side Transverses

5433 Side transverses in 'tween decks above fore peaks are to be in line with the peak side transverses and are to have a section modulus not less than required by 5427.

Side Longitudinals

5434 The section modulus of side longitudinals is to be in accordance with 5425.

Forecastles

5435 Web frames supporting side longitudinals are to have a section modulus not less than:—

$$\frac{I}{y} = 2{,}1\ C\ s_1\ h\ d\ \sqrt{D}\ cm.^3$$

Their depth is not to be less than twice that of the longitudinals.

5436 Side longitudinals in the forecastle are to have a section modulus not less than:—

$$\frac{I}{y} = \frac{s\ S^2}{132}\left(2 + \frac{D}{6}\right)\ cm.^3$$

5437 Pillars supporting the forecastle deck are, in general, to be spaced not more than 3,7 metres apart in the region forward of 0,04L abaft the forward perpendicular.

GENERAL

Deep Tanks Extending to Uppermost Continuous Deck

5438 Where in ships exceeding 180 metres in length, the deep tanks extend to the uppermost continuous deck and a centreline bulkhead only is fitted, the web frames and side transverses, which are to be in accordance with 5407 and 5424 respectively, are to be supported by one of the following methods:—

(1) A perforated flat situated at about half depth of tank and having a thickness not less than 9 mm. and an area of perforations not less than 10 per cent of the total area of the flat.
The section modulus of the girders and beams or longitudinals on the flat may be 50 per cent of that required for an intact flat in the same position.
Suitable transverses are to be arranged under the flat in way of the side transverses.

(2) A heavy side stringer at about half depth having a section modulus not less than:—

$$\frac{I}{y} = 12{,}6\ b\ h\ S^2\ cm.^3$$

where b = half the distance from the top of floors to deck at side, in metres.

h = distance, in metres, from stringer to upper deck at side amidships or to the highest point of tank, excluding the hatchway, whichever is the greater.

The ends of the stringer are to be connected to suitable stringers on the transverse bulkheads.

(3) Cross ties having scantlings required by D 4901 and having a vertical strut fitted at about mid-length. The dimensions of the strut are to be not less than those of the uppermost cross tie and it is to be effectively connected to the deck and bottom transverse and cross ties.

(4) Cross ties having scantlings required by D 4901 and having one or more fore and aft horizontal struts arranged to brace the cross ties between the deep tank bulkheads. The struts are to have a size appropriate to the cross ties supported.

5439 Where the longitudinal bulkheads are carried forward in deep tanks extending to the upper deck, the scantlings are to be as required by D46, D48 and D49.

Bulbous Bows

5440 The constructional arrangements required are dependent upon the shape and size of the bulb but, in general, the arrangement is to incorporate the following items:—

(i) Large bulbous bows are to have a centreline wash bulkhead and horizontal diaphragm plates spaced not more than 1 metre apart at the fore end of the bulb.

(ii) Small bulbous bows need not have a centreline wash bulkhead but are to have horizontal diaphragm plates spaced not more than 1 metre apart; normally these are to be in conjunction with a centreline web.

Where the length or width of a fore peak is unusually great due to fitting a bulbous bow, additional strengthening in the form of a transverse wash bulkhead at the mid-length of the peak-bulb space, may be required.

The shell plating in way of the bulb is, in general, to have a thickness required by D 1205. This increased plating should be extended to cover the areas likely to be damaged by the anchor and chain cables.

Continuity of Strength

5441 Continuity of strength is to be maintained at the scarphing of longitudinal and transverse framing and in cofferdams.

Construction of Bulkheads

5442 The scantlings of deep tank and peak tank bulkheads are to be in accordance with D 18 and D 19, as applicable. For cofferdam bulkheads, *see also* D 5308.

Construction of Deep Tank Top

5443 The scantlings and arrangements of the deep tank top are to be as required by D 1913 and D 1914.

Cross References

5444 For structural details, *see* D 57.

Section 55

(To be read in conjunction with Notice No. 5 to the 1966 Rules.)

STRUCTURAL ARRANGEMENTS AT THE AFTER END

5501 Symbols:

L = length of ship, in metres.

B = moulded breadth of ship, in metres.

D = moulded depth, in metres, to deck at side amidships.

d = moulded draught, in metres.

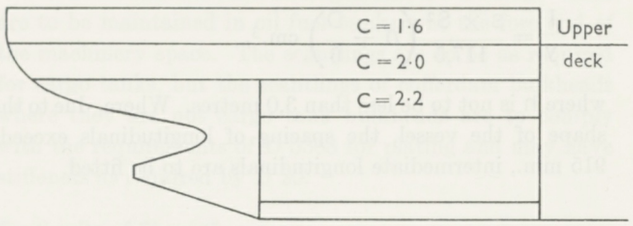
s = frame or longitudinal spacing, in mm.

s_1 = spacing of web frames or stringers, in metres.

S = span, in metres.

h = distance, in metres, from mid-point of span to upper deck at side amidships, unless stated otherwise.

C = a constant obtained from diagram.



Construction

5502 Aft of the forward machinery space bulkhead the requirements contained in the following sections are applicable to transverse or longitudinal systems of framing as appropriate. If a combination of these arrangements is adopted equivalent strength is to be provided.

Double Bottom

5503 The double bottom is to be transversely framed. The scantlings and arrangements of the double bottom in way of the main propulsion machinery are to be suitable for its type and power. Sufficient fore and aft girders should be arranged to effectively distribute the weight of the machinery and ensure adequate rigidity, and they are to extend aft under the thrust block seat. The tank top in way of the engine foundation should be substantially increased in thickness. The main engine seating should, in general, be integral with the double bottom structure; this particularly applies to higher power diesel and turbine installations. The general scantlings of the double bottom clear of the main machinery are to be not less than as follows:—

Minimum depth of centre girder D_{DB} =

$$\frac{1000B}{36} + 205\sqrt{d} \text{ mm.}$$

Thickness of centre girder = $0{,}008D_{DB}+4$ mm. but may be 10% less at aft end where clear of main engine seating.

Thickness of non-watertight floors and side girders = $0{,}008D_{DB}+1$ mm.

Thickness of watertight floors = non-watertight thickness + 2 mm. but need not exceed 15 mm.

$\frac{I}{y}$ of watertight floor stiffeners =

$$\frac{D^2_{DB} \times h_{DB} \times s_{DB}}{185 \times 10^6} \text{ cm.}^3$$

where D_{DB} = depth of double bottom, in mm.

h_{DB} = head from top of inner bottom to top of overflow pipe, in metres,

s_{DB} = stiffener spacing, in mm.

Minimum thickness of tank top plating is to be

$$0{,}00154\sqrt[4]{Ld}\,(s + 660) \text{ mm.}$$

TRANSVERSE FRAMING SYSTEM

Framing

5504 Main frames in the engine room are to have a section modulus in accordance with D 708(a).

5505 'Tween deck and poop side frames are to have a section modulus in accordance with D 708(a). Where horizontal stringers having scantlings required by 5508 are fitted, they may be considered to be decks for the purpose of calculating the required frame section modulus.

5506 Aft of the line of the after peak bulkhead, peak and 'tween deck frames are to be spaced as required by D 707. Peak frames are to have a section modulus in accordance with D 714 and 'tween deck and poop frames aft of the line of the after peak bulkhead are to have a section modulus in accordance with D 708(c).

Web Frame and Side Stringers

5507 Web frames are to be fitted in the machinery space below the lowest deck or flat, not more than five frame spaces apart.

5508 Where a horizontal stringer giving full support to the side framing is fitted below the lowest deck or flat, the web frame section modulus is to be based on a stress of 9,5 kg. per mm.^{2}, assuming fixed ends and point loading from the stringer, taking the head to upper deck at side amidships.

The section modulus of the stringer is not to be less than:—

$$7{,}75 \times s_1 \times h \times S^2 \text{ cm.}^3$$

5509 Where a horizontal stringer giving partial support to the side framing is fitted below the lowest deck or flat, the web frames are to have a section modulus not less than:—

$$7{,}75 \times s_1 \times h \times S^2 \text{ cm.}^3$$

The section modulus of the stringer is not to be less than:—

$$3{,}8 \times s_1 \times h \times S^2 \text{ cm.}^3$$

5510 Where no stringer is fitted the section modulus of the web frames is not to be less than:—

$$5{,}0 \times s_1 \times h \times S^2 \text{ cm.}^3$$

5511 The minimum depth of web frames in 5508, 5509 and 5510 is not to be less than two and a half times the depth of the adjacent side frames.

The thicknesses of web frames and horizontal stringer webs are to be the same.

5512 Above the lowest deck, or equivalent, webs are to be fitted in line with the web frames below the deck and are to extend to the uppermost continuous deck. The section modulus of these web frames is not to be less than:—

$$1{,}67 \times C \times s_1 \times S \times d \times \sqrt{D} \text{ cm.}^3.$$

Where there is no midship erection and all accommodation is fitted aft, sufficient web frames or partial bulkheads are to be fitted in the poop and in the superstructure above to ensure adequate transverse rigidity.

These webs should, in general, be in line with the web frames below the upper deck.

LONGITUDINAL FRAMING SYSTEM

Longitudinal Framing in Machinery Space

5513 In the machinery space the section modulus of the side longitudinals is not to be less than:—

$$\frac{I}{y} = \frac{s \times S^2}{153{,}5}\left(h + \frac{D}{6}\right) \text{ cm.}^3$$

where h is not to be less than 0,9 metres.

Web Frames

5514 The section modulus of transverse webs in machinery spaces situated below the lowest deck or equivalent flat and supporting side longitudinals is not to be less than:—

$$\frac{I}{y} = 10 \times s_1 \times h \times S^2 \text{ cm.}^3$$

The spacing of web frames is not to be more than required by 5507.

5515 Above the lowest deck or equivalent, webs are to be fitted in line with the web frames below the deck and are to extend to the uppermost continuous deck. The section modulus of the web frames is not to be less than:—

$$\frac{I}{y} = 2{,}1 \times C \times s_1 \times S \times d \times \sqrt{D} \text{ cm.}^3$$

5516 When longitudinal framing is adopted above the after peak, transverse webs are to be fitted in the 'tween decks not more than four frame spaces apart. The section modulus of these webs is not to be less than:—

$$\frac{I}{y} = 2{,}1 \times C \times s_1 \times S \times d \times \sqrt{D} \text{ cm.}^3$$

5517 The section modulus of side longitudinals above the after peak and abaft the after peak bulkhead is not to be less than:—

$$\frac{I}{y} = \frac{s \times S^2}{117{,}5}\left(h + \frac{D}{6}\right) \text{ cm.}^3,$$

where h is not to be less than 3,0 metres. Where, due to the shape of the vessel, the spacing of longitudinals exceeds 915 mm., intermediate longitudinals are to be fitted.

Poop Side Longitudinals

5518 Poop side longitudinals are to have a section modulus not less than:—

$$\frac{I}{y} = \frac{s\,S^2}{153{,}5}\left(2 + \frac{D}{6}\right) \text{ cm.}^3$$

GENERAL

After Peak

5519 Floors in the after peak and counter are to extend upward to the after peak tank top and are to have a thickness not less than that required by 5503. They are to be stiffened by flat bars or rolled sections of adequate size and spacing, bearing in mind possible vibratory forces which may arise in this region from the propeller. A centre-line wash bulkhead having the same thickness as the floors is to be arranged in the after peak tank and counter. When transverse framing in accordance with 5505 is fitted above the after peak, web frames or their equivalent are to be arranged in the 'tween decks at every fourth frame abaft the after peak bulkhead.

5520 Frames, floors, stringers, girders, stiffeners and wash bulkheads in the after peak, or on the after peak bulkhead are not to be scalloped and the connection to shell or bulkhead is to be by double continuous welds.

Decks

5521 Lower decks or flats are to have sufficient strength and adequate end fixity when they are intended to support webs and side frames.

Strong Beams and Pillars

5522 Strong beams or other efficient cross ties are, in general, to be fitted in way of large machinery openings and are to be associated with suitable web frames. An efficient pillaring system is to be provided under the engine casing and the casing sides are to be suitably stiffened in way of pillars. When the casing is used as a supporting girder suitable compensation is to be provided for openings.

Oil Fuel Bunkers

5523 The structural arrangements in the cargo tanks are to be maintained in oil fuel bunkers at the fore end of the machinery space. The scantlings are to be as required for cargo tanks, but the scantlings of cofferdam bulkheads where they are not cargo tank bulkheads are to comply with the requirements of D 5308 for plating and may have stiffeners as required by D 20.

Continuity of Strength

5524 Continuity of strength is to be maintained at the scarphing of longitudinal and transverse framing and in cofferdams.

The longitudinal deck framing is to extend one-third of the breadth of the ship into the poop. The side longitudinals are to extend abaft the poop front and the terminating positions of the longitudinal systems at sides and bottoms are to be staggered.

The longitudinal bulkheads are to extend well aft into the engine room and are to be suitably tapered at their ends.

Connections

5525 Web frames are to be suitably connected at top and bottom to members of adequate stiffness. Stringers are to be bracketed to the bulkheads. The stringer web and face plate are to be efficiently connected to the web frames.

Cross References

5526 For structural details and connections, *see* D 57. For section moduli of webs, girders, frames, etc., in association with plating, *see* D 53.

Section 56

(To be read in conjunction with Notice No. 5 to the 1966 Rules.)

SUPERSTRUCTURES AND DECKHOUSES

Forecastles

5601 All tankers are to be fitted with forecastles at least 0,07L in length measured from the fore perpendicular, except where, in ships exceeding 180 metres in length, the height of the upper deck above the summer load waterline measured at the forward perpendicular is as given in D 1702.

Superstructure Scantlings

5602 The scantlings of superstructures are to be as required by D 17, except that the upper limit of E_1 in D 1701, is to be 6,06 instead of 5,55. *See also* D 4202 and D 4203.

Deckhouse Scantlings

5603 The scantlings of deckhouses other than exposed casings and houses protecting openings to pump rooms are to be as required by D 17.

Houses Protecting Openings to Pump Rooms

5604 Houses protecting openings to pump rooms are to have end and side plating and end stiffeners as required for superstructures, irrespective of house size. The remaining items are to be as required for deckhouses.

Exposed Machinery Casings

5605 Exposed machinery casings, including the case where one end, or side, of a machinery casing forms part of an end or side of a superstructure or deckhouse, are to have scantlings as required by D 1706 and D 1707.

5606 There is not to be direct access to the machinery space from the freeboard deck.

Doors may be fitted in exposed machinery casings provided they lead to a space or passageway which is of equivalent strength to the casing, and is separated from the machinery space by a second weathertight door, *see* 5608.

Doors and Entrances

5607 Openings in poop fronts are to have sills not less than 450 mm. high.

5608 Doors in houses over pump rooms and in exposed machinery casings are to be of steel and weathertight. They are to be permanently attached by means of hinges and capable of being operated from both sides.

The door sills are to be not less than 600 mm. high if situated on the freeboard deck level, and not less than 380 mm. elsewhere.

General

5609 Where superstructures or deckhouses are of unusual design, additional strength may be required.

Section 57

STRUCTURAL DETAILS

Transverses, Webs, Stringers and Girders

5701 All primary supporting members, such as transverses and webs, stringers and girders, are to be so arranged that effective continuity of strength throughout their length is ensured and abrupt changes in depth or section at their connections are avoided; if the edges are flanged, the arrangement at the junction of the member and the bracket is to be of careful design and execution. Primary supporting members are to have adequate end fixity, web stiffening and lateral support.

All longitudinals, stiffeners, etc., are to be attached to the primary supporting member as required by Table 63E.

Arrangements at Ends of Primary Supporting Members

5702 When face plates are carried continuously along the edges of end brackets of primary supporting members, their butts are to be kept clear of the toes of the brackets. The full width of the face plate is to be determined as far as the span point.

If not carried along the edge of the bracket the face plates of these members are to extend a reasonable distance beyond the toes of the brackets.

Where a wide face plate abuts on a narrower face plate, the taper is generally not to exceed 1 in 3, elsewhere the taper may be 1 in 2. Where a thick face plate abuts on a thinner face plate, if the difference in thickness exceeds 3 mm., the taper on the thickness is not to exceed 1 in 3.

5703 End brackets are to be stiffened as follows:—

Length of free edge		Bracket stiffening	
Above	Not exceeding	Flange or face plate	Additional flat stiffener
mm.	mm.	mm.	mm.
—	1270	100	—
1270	1650	125	—
1650	2030	125	100
2030	2540	150	100
2540	—	200	125

The bracket stiffener, when required, is to be parallel to the free edge and generally not more than a quarter of the throat depth from it. Large brackets may also require stiffening in line with the girder face plate.

The thickness of the end bracket is not to be less than the thicker of the webs being connected unless additional stiffeners are fitted when the thickness may be reduced by 1 mm., provided the compartment minimum is maintained.

5704 Brackets are to be well hollowed out or attached to a flat on the bulkhead plating. The flat is to extend to an adjacent stiffener or is to be well tapered off.

End brackets to horizontal girders on the transverse bulkheads are to be carried to the adjacent transverse and vertical web or equivalent arrangements provided.

5705 The angle between the free edge of the bracket and the face plate of the primary member is not to exceed 45°; if necessary, the edge of the bracket is to be curved at the toe.

5706 Special attention is to be paid to the tripping brackets of girders or webs on corrugated bulkheads to avoid causing hard spots on the bulkhead. All brackets are to be well hollowed and are to be situated as close to the corner of the corrugation as practicable, or other suitable arrangements made to dissipate the load at the bracket toe.

5707 Where members abut on both sides of bulkheads or on other members care is to be taken that they are in alignment.

Web Stiffening

5708 Stiffeners are to be fitted to web plates at each frame, longitudinal or bulkhead stiffener except that on deck transverses and on side transverses and vertical webs within 0,25D from the deck at side, the stiffeners need only be fitted at alternate longitudinals. Elsewhere the spacing of stiffeners is generally not to be more than 1050 mm.

Flat bar stiffeners are to have the depth given in the following Table and minimum compartment thickness. Other types of stiffeners are to be of equivalent inertia.

Depth of Girder		Stiffeners	
Above	Not exceeding		
mm.	mm.	mm.	
—	610	75	Short and long alternately*
610	915	100	Short and long alternately*
915	1065	125	Short and long alternately*
1065	1220	125	All long
1220	1525	150	All long

* All long in way of end brackets.

Where the depth of the web exceeds 1525 mm. the stiffening arrangements will be specially considered, taking into account the number of attached girders, etc., and any stiffeners arranged parallel to the face plate of the girder.

Long stiffeners are to extend to the face edge of the web. In way of end brackets, or where required by 5713, the stiffeners are to be attached to the face plate or equivalent arrangements provided.

Short stiffeners are to extend to half the depth of the web but at least beyond the lightening holes or 150 mm. beyond the notches.

The requirements of Table 63E as regards area of weld are also to be complied with.

5709 Where bulkheads are horizontally corrugated and the vertical webs are arranged on one side of the bulkhead only, vertical stiffening of the web is to be provided when the depth of the web exceeds 1065 mm. The stiffener should be a 150×90 mm. toe welded angle of minimum compartment thickness or equivalent area.

5710 Vertical webs on plane transverse bulkheads are to be stiffened in accordance with 5709 when the depth of web exceeds 1900 mm. Similar stiffening may be required on other vertical webs when the depth is excessive.

5711 Stiffeners of the size given in 5708 are generally to be fitted to the deck centre line girder and bottom and deck side girders not more than 1050 mm. apart. All stiffeners are to extend to the face plate. In deep centre line girders horizontal stiffening is to be arranged.

Lateral Stability

5712 Tripping brackets are to be fitted at suitable intervals. In general, they should be fitted near the toes of end brackets and in way of cross ties, while arrangements at the intersections of longitudinal and transverse webs, vertical and horizontal webs should be adequate to prevent tripping. Where the span is long, additional brackets are to be fitted as necessary.

5713 Where the unsupported width of face plate exceeds 150 mm. the tripping bracket is to be connected to the face plate. Where, with symmetrically placed face plates, the width of face plate exceeds 400 mm. a small bracket connected to the face plate is to be fitted opposite, and in line with, the tripping bracket. Wide face plates may require to be supported between tripping brackets.

Notches

5714 All notches are to have well rounded corners and smooth edges and are not to be larger than necessary. When notches occur at points where stress concentration may develop, such as adjacent to the toes of brackets, a welded collar or equivalent reinforcement is to be fitted. Collars are also to be fitted in way of cross ties.

Lightening, Access, Drain and Air Holes and Holes for Heating Coils, etc.

5715 The diameter of lightening holes is not to exceed 20 per cent of the depth of the web; the edges of the holes should be placed at not less than 40 per cent of the depth of the web from the face and equidistant from the corners of notches for frames or stiffeners. Lightening holes are not to be cut in horizontal girders on the ship's side and longitudinal bulkheads, in symmetrical webs nor in side transverses and vertical webs in way of cross ties and their end connections. Access holes or foot holes may be cut in deep bottom transverses and centre girders with suitable compensation if necessary. All holes are to have smooth edges and are to be kept well clear of notches and the toes of brackets.

5716 Small drain or air holes may be cut in deep framing members and in longitudinals and stiffeners. These holes should be kept clear of the toes of end brackets and are to be well rounded with smooth edges. (*See also* D 4103 and Table 61 Note 4.)

5717 Where holes are cut in the bottom transverses for heating coils the lower edge of the hole is to be not less than 100 mm. from the inside of the shell plating.

5718 The edges of all holes in transverses are to be at least 180 mm. from the edges of notches for longitudinals.

Welded Connections

5719 The requirements for welded connections and details of scalloped construction are given in Table 63. All scallops are to have well rounded corners and smooth edges. (For general particulars *see* Table 63A.) Scallops are not to be cut in way of end brackets, and scallops in the stiffening members are to be at least 230 mm. clear of the toe of the bracket. Scallops in longitudinals, side frames and stiffeners are also to be omitted for at least 230 mm. on each side of intersection with a primary supporting member. Scallops are not to be cut in bottom transverses or in horizontal

girders on ship's side or longitudinal bulkheads, and in ships over 122 metres in length, scallops are not to be cut in the lower half of side transverses or vertical webs on longitudinal and transverse bulkheads.

16th June, 1966

Riveted Connections

5720 In riveted construction arrangements are to be generally equivalent to the requirements of this Section and the riveting is to be as required by Table 63.

VALUES OF K

LENGTH L	K	Difference in K per 5 metres difference in L	LENGTH L	K	Difference in K per 5 metres difference in L	LENGTH L	K	Difference in K per 5 metres difference in L
Metres			Metres		0,198	Metres		0,335
90	0,747		**165**	2,950		**240**	7,025	
		0,106			0,207			0,344
95	0,865		**170**	3,157		**245**	7,369	
		0,109			0,215			0,354
100	0,985		**175**	3,372		**250**	7,723	
		0,112			0,224			0,363
105	1,106		**180**	3,596		**255**	8,086	
		0,116			0,234			0,372
110	1,228		**185**	3,830		**260**	8,458	
		0,120			0,244			0,381
115	1,351		**190**	4,074		**265**	8,839	
		0,125			0,255			0,390
120	1,476		**195**	4,329		**270**	9,229	
		0,130			0,265			0,399
125	1,606		**200**	4,594		**275**	9,628	
		0,138			0,274			0,408
130	1,744		**205**	4,868		**280**	10,036	
		0,147			0,282			0,417
135	1,891		**210**	5,150		**285**	10,453	
		0,155			0,290			0,426
140	2,046		**215**	5,440		**290**	10,879	
		0,164			0,299			0,435
145	2,210		**220**	5,739		**295**	11,314	
		0,172			0,308			0,444
150	2,382		**225**	6,047		**300**	11,758	
		0,181			0,317			0,454
155	2,563		**230**	6,364		**305**	12,212	
		0,189			0,326			
160	2,752		**235**	6,690				
		0,198			0,335			

TABLE 61

REQUIRED KEEL MODULUS	BASIC AREA	BASIC DEPTH D_1	DEPTH CORRECTION
1	2	3	4
cm.³	cm.²	metres	cm.²
1×10^6	870	5,70	130
2×10^6	1305	7,30	150
3×10^6	1665	8,50	170
4×10^6	2000	9,45	185
6×10^6	2590	10,75	210
8×10^6	3145	11,80	225
10×10^6	3675	12,55	255
14×10^6	4665	13,75	295
18×10^6	5585	14,70	330
23×10^6	6700	15,65	370
29×10^6	8010	16,65	410
37×10^6	9630	17,85	470
47×10^6	11540	19,00	530
57×10^6	13420	19,95	590
71×10^6	15860	21,20	675
85×10^6	18280	22,10	750

NOTES.—TABLE 61

1. Where the depth D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than the basic depth D_1 the tabular bottom area is to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ at the rate per metre of difference given in column 4.

2. The bottom area is that for one side of the ship and includes the following items up to 0,1D from the base line:—
   - One half the keel plate
   - Bottom and bilge plating
   - Bottom, bilge and side longitudinals
   - One half the centre girder
   - Side girders
   - Plating and longitudinal stiffeners of longitudinal bulkheads (including one half of a centre line bulkhead).

3. The deck area is that for one side of the ship in way of openings and includes the following items down to 0,1D from the deck line at side:—
   - Deck stringer and plating
   - Sheerstrake
   - Stringer angle (if fitted)
   - Deck and side longitudinals
   - One half the centre line deck girder
   - Side girders
   - Plating and longitudinal stiffeners of longitudinal bulkheads (including one half of a centre line bulkhead).

4. Elliptical deck openings need not be deducted provided their major axes are fore and aft, the ratio of the length to breadth of each opening is not less than 2:1 and the total breadth of such openings in a transverse section does not exceed 0,06B.

Lightening holes in girders need not be deducted provided their depth does not exceed 20 per cent of the depth of the girder web.

Where longitudinals are scalloped the net area in way of scallop is to be used. Isolated drain holes need not be deducted, but compensation will be required for large drain holes at the bulkheads.

5. For permissible reductions when an approved system of corrosion control is fitted *see* D 4018.

WELDING AND RIVETING

A

TYPES OF WELDING

SIZE OF FILLET WELDS

PLATING THICKNESS	BASIC THROAT THICKNESS
mm.	mm.
6,0	4,0
7,5	4,5
9,0	5,0
10,5	5,5
12,0	6,0
14,0	6,5
16,0	7,0
18,0	8,0
20,5	9,0
23,0	10,0
25,5	11,0

NOTES.—TABLE 63A

1. **Basic throat thickness** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of fillet will be specially considered.

2. **Basic throat thickness** for intermediate thickness to be obtained by direct interpolation.

3. **Throat thickness for double continuous fillets** is the product of Basic Throat Thickness and the Weld Factor required by Tables 63G and 63H.

4. **Throat thickness for intermittent fillets** is to be given by the formula

Throat thickness = Basic Throat Thickness × Weld Factor × $\frac{d}{s}$ where s and d are as defined in the sketches below. The length s should not be less than 75 mm. and s and d are to be such that the required throat thickness does not exceed the Basic Throat Thickness.

5. **Minimum throat thickness** of fillet weld to be 0,80 of the Basic Throat Thickness except where a reduction is allowed by Notes to Tables 63E, 63G and 63H. In no case is the throat thickness to be less than 3,5 mm.

6. **Leg length** of welds is not to be less than 140 per cent of the required throat thickness.

STAGGERED INTERMITTENT

To be doubled at ends. *See* D 3117

CHAIN INTERMITTENT

SCALLOPED FRAMES, LONGITUDINALS, STIFFENERS, etc., WITH DOUBLE FILLET WELDS

Welding to be carried round the ends of all lugs

See also D 5719

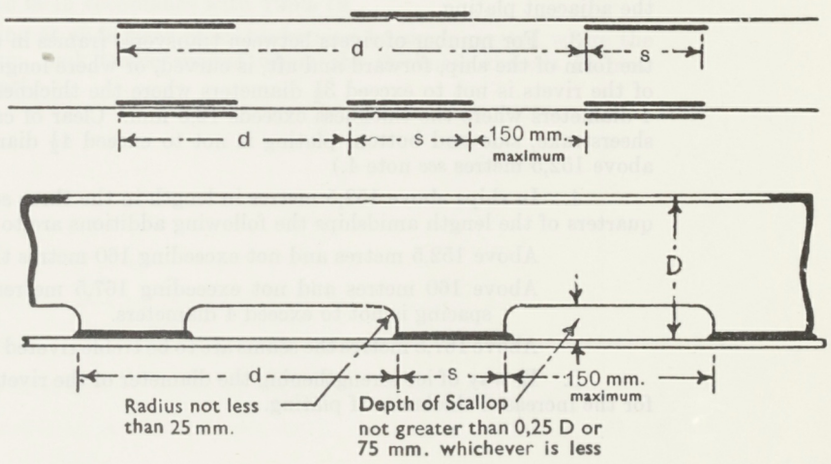


TABLE 63 B

WELDING AND RIVETING

B

RIVETING OF SEAMS OF SHELL PLATING

ITEM	THICKNESS		SEAMS			
	Above	Not exceeding	Diameter of rivets	Type	Breadth	Spacing of rivets centre to centre
	mm.	mm.	mm.		mm.	mm.
Sheerstrake between 0,25L aft of amidships and 0,2L forward of amidships	*See* note 2					
Bottom plating from keel to upper turn of bilge between 0,25L aft of amidships and 0,2L forward of amidships		12,5	19	Double	115	65
	12,5	18,5	22	Double	135	90
	18,5	24	25	Double	150	100
	24	32	28	Double	170	115
	32	38	28	Treble	240	115
Sheerstrake at ends Side shell plating from upper turn of bilge to sheerstrake Bottom plating from keel to upper turn of bilge at ends		12,5	19	Double	115	65
	12,5	18,5	22	Double	135	90
	18,5	24	25	Double	150	100
	24	29	28	Double	170	115
Keel	*See* note 2					

See notes 4 & 5

NOTES.—TABLE 63 B

1. Double riveted seams in association with 31 mm. rivets may be fitted as an alternative to treble riveted seams and 28 mm. rivets.

2. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the adjacent plating.

3. For number of rivets between transverse frames in seams of side plating *see* Table 63D. Where the form of the ship, forward and aft, is curved, or where longitudinal side framing is adopted, the spacing of the rivets is not to exceed $3\frac{1}{2}$ diameters where the thickness of plating does not exceed 12,5 mm. and 4 diameters where the thickness exceeds 12,5 mm. Clear of cargo tanks the spacing of rivets in seams of sheerstrake, side and bottom plating is not to exceed $4\frac{1}{2}$ diameters. (For special requirements for ships above 152,5 metres *see* note 4.)

4. In ships above 152,5 metres in length in the three seams nearest the neutral axis and for three-quarters of the length amidships the following additions are to be made:—

Above 152,5 metres and not exceeding 160 metres the spacing is not to exceed $3\frac{1}{2}$ diameters.

Above 160 metres and not exceeding 167,5 metres the seams are to be treble riveted and the spacing is not to exceed 4 diameters.

Above 167,5 metres the seams are to be treble riveted and the spacing is not to exceed $3\frac{1}{2}$ diameters.

5. In way of ice strengthening the diameter of the rivets used may be 3 mm. less than that required for the increased thickness of plating.

WELDING AND RIVETING

C

RIVETING OF SEAMS OF DECK PLATING

ITEM	THICKNESS		SEAMS			
	Above	Not exceeding	Diameter of rivets	Type	Breadth	Spacing of rivets centre to centre
	mm.	mm.	mm.		mm.	mm.
Strength deck stringer plate	*See* note 2					
Strength deck plating		12,5	19	Double	115	*See* note 4
	12.5	18,5	22	Double	135	90
	18,5	24	25	Double	150	100
	24	32	28	Double	170	115
	32	38	28	Treble	240	115
Sheerstrake stringer connection	*See* note 3					

NOTES.—TABLE 63 C

1. Double riveted seams in association with 31 mm. rivets may be fitted as an alternative to treble riveted seams and 28 mm. rivets.

2. In seams of stringer plates the diameter of rivets and number of rows are to be regulated by the thickness of adjacent deck plating.

3. The sheerstrake stringer connection is to be double riveted over the cargo tanks and for $\frac{1}{3}$B into the poop. Where the length L exceeds 228,5 metres, or where the seams of the deck plating are to be treble riveted, the sheerstrake stringer connection is also to be treble riveted. The diameter of the rivets is to be governed by the thickness of the stringer bar and the rivets are to be spaced 5 diameters apart in each row. At the end of the ship the riveting is to be in accordance with Table 19.

4. The seams of strength deck plating at ends clear of oil tanks may be single riveted where the thickness of plating does not exceed 18 mm. and double riveted where the thickness exceeds 18 mm. The rivets are to be spaced $4\frac{1}{2}$ diameters apart.

TABLE 63 D

WELDING AND RIVETING

D

NUMBER OF RIVETS IN SEAMS OF SIDE SHELL PLATING BETWEEN TRANSVERSE FRAMES EXCLUDING RIVETS IN FRAMES

FRAME SPACING	THICKNESS OF SIDE SHELL IN MILLIMETRES		
	Not exceeding 12,5	Above 12,5 and not exceeding 18,5	Above 18,5 and not exceeding 24
	DIAMETER OF RIVET IN MILLIMETRES		
	19	22	25
	NUMBER OF RIVETS IN EACH ROW		
Millimetres			
610	8	6	
620	8	6	
630	9	6	
640	9	7	
650	9	7	
660	9	7	6
670	9	7	6
680	9	7	6
690	9	7	6
700	10	7	6
710	10	7	6
720	10	7	6
730	10	8	7
740	10	8	7
750	10	8	7
760	11	8	7
770	11	8	7
780	11	8	7
790	11	8	7
800	11	8	7
810	11	8	7
820		9	7
830		9	8
840		9	8
850		9	8
860		9	8
870		9	8
880		9	8
890		9	8
900		9	8
910		10	8
920		10	8

NOTES.—TABLE 63 D

1. For spacing of rivets clear of cargo tanks and where the form of the ship is curved *see* Table 63 B, Note 3.
2. For special requirements in ships above 152,5 metres in length *see* Table 63 B, Note 4.

WELDING AND RIVETING

E

CONNECTIONS OF LONGITUDINALS, FRAMES AND STIFFENERS TO PRIMARY SUPPORTING MEMBERS

1. The area of welds connecting longitudinals, frames and stiffeners to primary supporting members is not less than that given by the formula

$$A = 0{,}88\sqrt{\frac{I}{y}} \text{ or 13 square cm., whichever is greater,}$$

where A = Area of weld in square cm. as defined in 2 below,

$\frac{I}{y}$ = Section modulus of longitudinal, frame or stiffener in $cm.^3$

2. Area of weld is the product of the throat thickness and the total length of weld and includes both weld of web connection and weld of connection to stiffening bar. The throat thickness is not to be less than 80 per cent of that of the weld required by Table 63A.

3. The area of weld required by 1 above is for bottom and side transverses; for deck transverses the area of weld is not to be less than half the value required by the formula.

4. Outside the tank space the area of weld may be 80 per cent of the value required by the formula and associated notes. The throat thickness of weld is not to be less than 67 per cent of that of the weld required by Table 63A with a minimum of 3,5 mm.

WELDING AND RIVETING

F

BRACKETS AT HEAD OF SIDE FRAMES AND AT ENDS OF VERTICAL STIFFENERS TO LONGITUDINAL AND TRANSVERSE BULKHEADS

1. The dimensions of brackets and their connections are not to be less than those given by the following formulæ:—

Length of Arm (l) $= 28{,}3\sqrt{\frac{I}{y}} + 50$ mm.

Thickness $= 0{,}184\sqrt{\frac{I}{y}} + 6{,}5$ mm. or 9 mm., whichever is greater but need not exceed 12,5 mm.

Flange Width (see 4 below) $= 3{,}14\sqrt{\frac{I}{y}} + 12{,}5$ mm. or 100 mm. whichever is less.

Weld area (see 2 below) $= 0{,}042\ l$ square centimetres if $l \leq 610$ mm.

,, $= 0{,}064\ l - 13$ square centimetres if $l > 610$ mm.

Dia. of Rivets = 19 mm. if $\frac{I}{y} \leq 245$ cm.^{3}

,, = 22 mm. if $\frac{I}{y} > 245$ cm.^{3}

Number of Rivets $= 0{,}346\sqrt{\frac{I}{y}} + 0{,}5$ for 19 mm. rivets.

,, $= 0{,}346\sqrt{\frac{I}{y}} - 0{,}7$ for 22 mm. rivets.

Where $\frac{I}{y}$ = Section modulus of frame or stiffener in cm.^{3}

2. Area of weld is the product of the throat thickness and the total length of weld, but the throat thickness is not to be less than 80 per cent of that of the weld required by Table 63A.

3. Length of bracket arm is to be measured from the plating.

4. Flanges need not be fitted where the length of bracket arm is less than 460 mm.

5. For minimum thickness *see* D 5308.

WELDING AND RIVETING

G

CONNECTION OF PRIMARY SUPPORTING MEMBERS TO FACE MATERIAL, SHELL, DECK AND BULKHEAD

FACE AREA		POSITION	WELDED		RIVETED		
			TO FACE MATERIAL	TO SHELL, DECK OR BULKHEAD	TO FACE MATERIAL	TO SHELL, DECK OR BULKHEAD	
			WELD FACTOR	WELD FACTOR	MAXIMUM SPACING OF RIVETS, CENTRE TO CENTRE IN DIAMETERS	NUMBER OF ROWS	MAXIMUM SPACING OF RIVETS, CENTRE TO CENTRE IN DIAMETERS
Square Centimetres							
Above	Not exceeding						
	30,0	For a distance each end equal to 0,2 × length	0,33	0,67	7	Double	5
		Remainder	0,21	0,33	7	Single	5
30,0	**65,0**	For a distance each end equal to 0,2 × length	0,50	0,80	4	Double	5
		Remainder	0,25	0,60	6	Double	5
65,0	**95,0**	For a distance each end equal to 0,2 × length	0,80	1,00	5	Double with single riveted backbar	$4\frac{1}{2}$
		Remainder	0,80*	0,80	6	Double	$4\frac{1}{2}$
95,0	**130,0**	For a distance each end equal to 0,2 × length	0,80	1,00	4	Double with single riveted backbar	4
		Remainder	0,80*	0,80	5	Double	4
130,0	**260,0**	For a distance each end equal to 0,2 × length	1,00	1,00			
		Remainder	0,80	1,00			

* May be 0,67 clear of oil cargo tanks

NOTES.—TABLE 63 G

1. Length for use in the above Table is the unsupported length of the member including end connections.

2. The extent of the increased connection at each end equal to 0,2 × length given in the above Table is measured from the end of the member including the end bracket, but this length is to be extended as necessary beyond the toe of the bracket, and beyond the heel of the bracket to cover a contiguous member.

3. On vertical webs the increased welding or riveting may be omitted at the top, but at the bottom it is to extend for a distance equal to 0,3 × length.

4. In ships over 122 metres long the weld factor of the connection of bottom transverses to the shell is not to be less than 0,80 and that of the side transverses to shell, and the vertical webs to longitudinal and transverse bulkheads is not to be less than 0,80 in the lower half; in riveted ships these connections are not to be less than double riveted angles.

5. Centre line deck and bottom girders are to be welded or riveted as given in the above Table.

6. For particulars of scalloped construction *see* D 5719 and notes under Table 63A.

TABLE 63 H
(SEE CONTINUATION)

WELDING AND RIVETING

H

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	WELDED: WELD FACTOR	RIVETED: MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
FRAMES & LONGITUDINALS		
Side frames to shell — in cargo tanks, spacing not over 760 mm. ...	0,25	6
Side frames to shell — in cargo tanks, spacing over 760 mm. ...	0,27	5½
Side frames to shell — in deep, oil fuel and peak tanks	0,27	5½
Side frames to shell — in fore hold	0,27	5½
Side frames to shell — in machinery space, spacing not over 740 mm.	0,21	7
Side frames to shell — in machinery space, spacing over 740 mm. and up to 810 mm.	0,23	6½
Side frames to shell — in machinery space, spacing over 810 mm. and up to 860 mm.	0,25	6
Side frames to shell — in machinery space, spacing over 860 mm. ...	0,27	5½
Tween deck frames and longitudinals to shell	0,21	7
Web frames	*See* Table 63 G	
Bottom longitudinals to shell (except as below) — Where the length L does not exceed 122 metres — For a distance either side of the bulkhead equal to 0,25 × spacing of transverses	0,80	4
Bottom longitudinals to shell (except as below) — Where the length L does not exceed 122 metres — remainder (except in the forward 0,25 L)...	0,25	6
Bottom longitudinals to shell (except as below) — Where the length L does exceed 122 metres — For a distance either side of the bulkhead equal to 0,30 × spacing of transverses	0,80	3½ with back angle
Bottom longitudinals to shell (except as below) — Where the length L does exceed 122 metres — remainder (except in the forward 0,25 L)...	0,25	6
Bottom longitudinals to shell (except as below) — In the forward 0,25 L (except at the ends of span, where as above)	0,50	4½ with back angle
Bottom longitudinals of flatbar type to shell	Continuous weld—throat thickness 25 per cent of thickness of the thinner member being connected but need not exceed 5,5 millimetres (manual) or 4,5 millimetres (automatic).	
Side longitudinals to shell (*cont. next page*) — Not over 4,6 metres below upper deck at side amidships	0,25	6
Side longitudinals to shell (*cont. next page*) — over 4,6 metres and not over 7,6 metres below upper deck at side amidships — For a distance either side of bulkhead equal to 0,25 × spacing of transverses ...	0,80*	4½
Side longitudinals to shell (*cont. next page*) — over 4,6 metres and not over 7,6 metres below upper deck at side amidships — remainder	0,25	6

* May be 0,67 clear of oil cargo tanks

For notes see page 256

WELDING AND RIVETING

H (*continued*)

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	WELDED	RIVETED
	WELD FACTOR	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
Side longitudinals to shell (*continued*) — Over 7,6 metres below upper deck at side amidships — For a distance either side of bulkhead equal to 0,25 × spacing of transverses ...	0,80	$3\frac{1}{2}$
Side longitudinals to shell (*continued*) — Over 7,6 metres below upper deck at side amidships — remainder	0,25	6
Deck longitudinals to deck plating, except as below	0,25	6
Deck longitudinals of flatbar type to deck plating...	Continuous weld—throat thickness 25 per cent of thickness of the thinner member being connected but need not exceed 5,5 millimetres (manual) or 4,5 millimetres (automatic).	
Longitudinals to stiffening bars on primary supporting members ...	*See* Table 63 E	
Intercostal bottom side girders to shell	As for bottom longitudinals	
Intercostal deck side girders to deck plating	As for deck longitudinals	
Face bar of intercostal bottom and deck side girders to respective web plates	0,30	7
Bottom frames to shell and floors forward	0,50	$5\frac{1}{2}$—double riveted
Floors to centre girder or centre line bulkhead forward	1,00	4—double riveted
Floors and cross ties in fore peak	0,25	6
Floors and cross ties in after peak	0,30	5
PRIMARY SUPPORTING MEMBERS		
Bottom transverses to shell	*See* Table 63 G	
Side transverses to shell		
Deck transverses to deck plating		
Web frames to shell		
Vertical webs on longitudinal and transverse bulkheads ...		
Stringers to shell		
Horizontal girders to O.T. bulkheads		
Bottom transverses to longitudinal bulkheads and centre line girders	1,00	
Deck transverses to longitudinal bulkheads and centre line girders	0,80	5—double riveted
BRACKETS		
End brackets to all primary supporting members	1,00	
Brackets at head of side frames	*See* Table 63 F	
Side frames to bilge brackets	To depend on arrangements adopted.	
End connections of longitudinals	Generally 1,00 but to depend on design.	
Brackets at ends of stiffeners on transverse bulkheads	To depend on end connections of longitudinals	
Tripping brackets	0,25	6
Docking brackets	0,30	5
Stiffening of primary supporting members *See also* Table 63 E ...	0,21	7

For notes see page 256

TABLE 63 H
(CONCLUDED)

WELDING AND RIVETING

H (*concluded*)

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM					WELDED: WELD FACTOR	RIVETED: MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
O.T. TRANSVERSE & LONGITUDINAL BULKHEADS						
Vertical stiffeners	spacing not exceeding 760 mm.				0,25	6
	spacing exceeding 760 mm.				0,27	$5\frac{1}{2}$
Horizontal stiffeners	Not over 4,6 metres below highest point of tank ...				0,25	6
	on longitudinal bulkheads	over 4,6 metres and not over 7,6 metres	For a distance either side of bulkhead equal to 0,25 × spacing of transverses		0,80	$4\frac{1}{2}$
			remainder		0,25	6
		over 7,6 metres	For a distance either side of bulkhead equal to 0,25 × spacing of transverses		0,80	$3\frac{1}{2}$
			remainder		0,25	6
	on transverse bulkheads	Not over 5,5 metres below highest point of tank ...			0,25	6
		over 5,5 metres			0,30	5
Boundaries	of longitudinal bulkheads to bottom or deck ...				1,00 (continuous) *See* note 2.	5—double riveted
	of transverse bulkheads	to shell at bottom or bilge ...			1,00 (continuous)	5—double riveted
		to shell at sides or to deck ...			0,80 (continuous)	5—double riveted
		to longitudinal bulkheads ...			0,80 (continuous)	5—double riveted
Vertical webs ... ... Horizontal girders					*See* Table 63 G	

NOTES.—TABLE 63 H

1. Within the cargo tanks double continuous fillets having a throat thickness of less than 0,80 of the Basic Throat Thickness (Table 63A) are to be restricted to longitudinal framing and to bulkhead stiffening, and, apart from longitudinals of the flatbar type, are to have a minimum throat thickness of 3,5 mm. or 0,67 of the Basic Throat Thickness, whichever is greater.

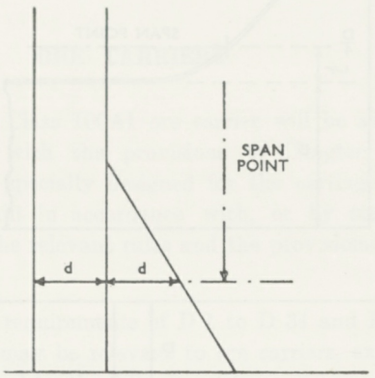
2. Where the top and bottom strakes of the longitudinal bulkhead are increased in thickness above the requirements of D 5006 the welding to deck or bottom shell is not to be less than that based on the thickness required by D 5006 or a throat thickness 25 per cent of the actual plating thickness, whichever is the greater.

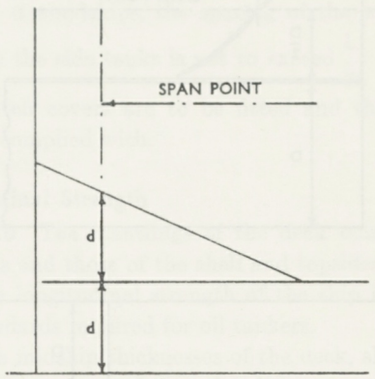
3. The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to 22 mm. in diameter and three-and-a-half times for rivets 25 mm. and above in diameter.

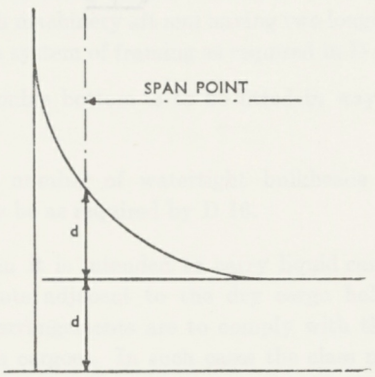
4. The distance from the centre of the rivet hole to the edge of the angle is to be not less than one-and-a-half rivet diameters.

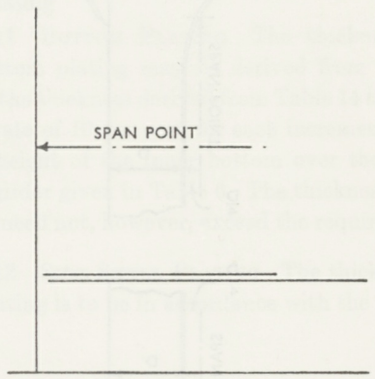
SPAN POINT

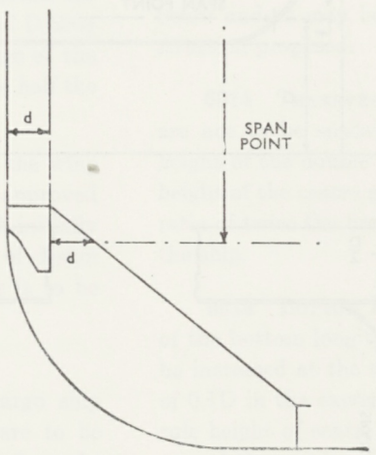
FOR LONGITUDINALS, FRAMES AND STIFFENERS





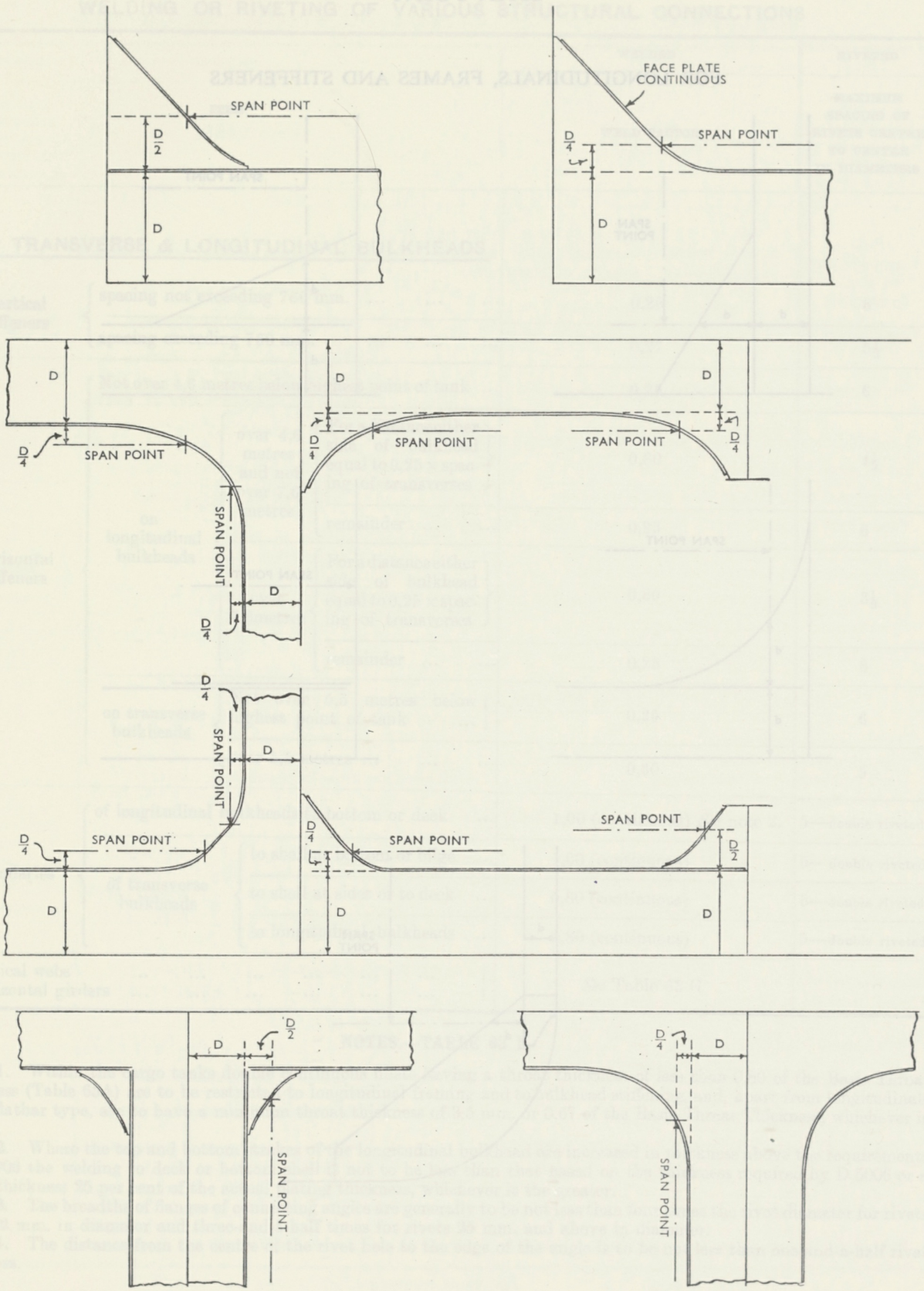






SPAN POINT

FOR PRIMARY SUPPORTING MEMBERS



SHIPS SPECIALLY DESIGNED FOR CARRYING ORE

Section 60

ORE CARRIERS

General

6001 The Class 100A1 ore carrier will be assigned, in accordance with the provisions of Chapter B, to sea-going ships specially designed for the carriage of ore cargoes and built in accordance with, or by standards equivalent to, the relevant rules and the provisions of this Section.

6002 The requirements of D 1 to D 34 and D 40 to D 57 apply as may be relevant to ore carriers, except as otherwise required by the following rules.

Structural Design

6003 The following rules are intended for single deck ore carriers, with machinery aft and having two longitudinal bulkheads and a system of framing as required in D 4003.

6004 A double bottom is to be fitted in way of the cargo holds.

6005 The number of watertight bulkheads in the cargo holds may be as required by D 16.

6006 When it is intended to carry liquid cargoes in the compartments adjacent to the dry cargo holds, the scantlings and arrangements are to comply with the rules relevant to such cargoes. In such cases the class notation may be suitably modified.

6007 When an approved system of corrosion control is fitted in the wing tanks or tanks under ore holds, the reduction in scantlings given in D 4018, D 5308 and D 5309 can generally be applied except that the thickness of the longitudinal bulkhead may only be reduced by one half the allowance given.

6008 When low flash point oil is carried in the wing tanks and anodes are fitted, they are to be of approved design and securely attached to the structure, both initially and during service. A plan showing the details of design and attachement and the location of the anodes is to be submitted.

Draught

6009 When a draught in excess of the cargo ship draught is desired, the longitudinal bulkheads are to be not less than 0,2B from the ship's sides measured at the draught d amidships, the spacing of the watertight bulkheads in the side tanks is not to exceed $\frac{L}{24} + 6{,}10$ metres, steel hatch covers are to be fitted and the provisions of D 5601 complied with.

Longitudinal Strength

6010 The scantlings of the deck outside the line of openings and those of the shell and topsides are to be such that the longitudinal strength of the ship is equivalent to the standards required for oil tankers.

The midship thicknesses of the deck, shell and topside plating are to extend over the distances required by D 42 and D 43.

Shell Plating

6011 Bottom Plating The thickness of the keel and bottom plating may be derived from D 7 and Table 14, but the thickness derived from Table 14 is to be increased at the rate of 10 per cent for each increment of 0,1D in the excess height of the inner bottom over the rule height of centre girder given in Table 6. The thickness of the bottom plating need not, however, exceed the requirements of D 43.

6012 Side Shell Plating The thickness of the side shell plating is to be in accordance with the requirements of D 43.

Double Bottom Structure

6013 The scantlings and arrangements in the double bottom are generally to be governed by D 5 modified as below and as may be necessary to suit the details of construction proposed.

6014 Transverses Transverses under cargo holds are not to be spaced more than 2,45 metres apart. The height of the double bottom is not to be less than the rule height of the centre girder given in Table 6 increased in the ratio of twice the breadth of the ore hold to the breadth of the ship.

6015 Bottom Longitudinals The section modulus of the bottom longitudinals as derived from Table 10 is to be increased at the rate of 50 per cent for each increment of 0,1D in the excess height of the double bottom over the rule height of centre girder given in Table 6, but need not exceed the requirements of D 44.

6016 INNER BOTTOM LONGITUDINALS The section modulus of the inner bottom longitudinals as derived from Table 10 is to be increased in the ratio of breadth of ship to breadth of ore hold, but is to be at least 20 per cent above the requirements of D 5.

Struts should not be fitted to the longitudinals between the floors.

6017 INNER BOTTOM PLATING The thickness of the inner bottom plating is to be increased by 5 mm. above the requirements of Table 6, or alternatively a double ceiling is to be fitted.

Side and Deck Longitudinals

6018 Side and deck longitudinals are to be in accordance with the requirements of D 44.

28th February, 1963

Transverse Side Framing

6019 Transverse side frames are to be in accordance with the requirements of D 45.

Hatch Covers

6020 Steel hatch covers are to be in accordance with D 2326 and the scantlings determined from the formulæ given in Table 43, note 6. When a draught in excess of the cargo ship draught is desired, the section modulus and moment of inertia of the stiffeners and thickness of the plating are to be increased by 15 per cent.

Equipment

6021 The equipment is to be in accordance with D 33.

6022 Special consideration is to be given to details of construction not specifically mentioned in the above rules.

APPLICATION OF HIGHER TENSILE STEEL

Section 65

GENERAL

6501 Where higher tensile steel is extensively used in the main hull structure, a suitable descriptive notation will be inserted in the Register Book.

6502 To facilitate ordering of material for repairs, it is recommended that a plan should be placed on board indicating the location and extent of the higher tensile steel, together with details of the specification, including mechanical properties, of the steel.

Method of Construction

6503 The following requirements are applicable to ships where the bottom and deck are framed longitudinally. Proposals with transverse framing will be specially considered.

Material

6504 The higher tensile steel to be used is to comply with the requirements of P 219 to P 227.

6505 For scantling purposes a factor k shall be derived for the steel as follows:—

$$k = \frac{70,9}{Y + U}$$

where Y = specified minimum upper yield stress or 0,5% proof stress in kg. per mm.^{2} or 0,7U whichever is the less.

U = specified minimum tensile strength plus one-half of the specified range, in kg. per mm.^{2}.

Special consideration will be given to steels where Y is less than $0,5 \times U$.

Section 66

LONGITUDINAL STRENGTH

6601 The required section moduli at deck and keel, as determined from D 3 or D 41, are to be multiplied by the factor k or by $0,0625\frac{L}{D}$, whichever is the greater. Where both higher tensile steel and ordinary mild steel are used for continuous longitudinal members, the whole of the topsides and the bottom is to be of higher tensile steel to a distance from deck and bottom at least equal to $(1-k)y$ or $\left(1-0,0625\frac{L}{D}\right)y$, whichever is the lesser, where y is the distance from the neutral axis to the deck or bottom.

Section 67

LOCAL STRENGTH

6701 The requirements of the following paragraphs should be applied to the scantlings of the structural members as determined from the appropriate section of the Rules.

Shell Plating

6702 The thickness of side shell is to be reduced by the factor $\sqrt{k}$. The minimum thickness of bottom shell plating may be reduced by the factor $\frac{2k+\sqrt{k}}{3}$ subject to compliance with longitudinal strength requirements.

Deck Plating

6703 The thickness of deck plating is to be determined by longitudinal strength requirements, and the minimum thickness may be reduced by the factor $\frac{2k+\sqrt{k}}{3}$

Longitudinal Framing

6704 The section modulus of deck, side, bottom and inner bottom longitudinals is to be multiplied by the factor k.

The spacing of deck and bottom longitudinals, in millimetres, is not to be greater than $65\ t\sqrt{k}$, where t is the thickness of the deck plating or bottom shell, as appropriate, in millimetres.

Girders

6705 The section modulus of deck and bottom girders is to be multiplied by the factor k.

Double Bottom

6706 The height of the double bottom is to be as required by the appropriate section of the Rules, but the thicknesses of floors, girders and tank top are to be multiplied by the factor $\sqrt{k}$. The factor should be applied to the Rule thickness of tank top plating and the full increase

for grab discharge (if applicable) added to this corrected thickness.

Bulkheads

6707 The section modulus of the stiffeners is to be multiplied by the factor k and the plating thickness by the factor $\sqrt{k}$. Corrugated bulkheads may be similarly treated except that the minimum moment of inertia shall not be reduced.

Cross Ties

6708 The area of cross ties is to be multiplied by the factor k. The least moment of inertia shall not be reduced.

16th June, 1966

Minimum Thickness

6709 The minimum thickness of structural items is to be reduced by the factor $\sqrt{k}$.

Riveting

6710 Riveting is to be based on a nominal plating thickness equal to:—

$$\frac{\text{H.T. Steel Thickness}}{k}$$

REQUIREMENTS FOR THE CARRIAGE OF LIQUEFIED GASES

(The attention of Builders and Owners is directed to the fact that compliance with these Rules may involve the obtaining of licences under existing patents.)

Section 70

GENERAL

Class

7001 The class 100A1 Liquefied Gas Carrier, type of gas(es) in independent tanks, maximum vapour pressure, minimum temperature and, where necessary, maximum temperature (to be specified), will be assigned to ships specially designed for the carriage of liquefied petroleum natural or other gases in separate tanks and built in accordance with, or equivalent to, the relevant sections of the Rules and the requirements in this section in conjunction with D 71 or D 72 as appropriate.

These requirements are primarily intended to apply to ships having machinery aft and built for the carriage of liquefied petroleum or natural gases in separate tanks and special consideration will be given to the requirements necessary for other liquefied gases.

Longitudinal Strength

7002 The required section modulus at deck and keel is to be determined in accordance with D 3705 and D 3706 of the Rules as required therein for the class 100A1. For ships less than 121,9 metres in length k is to be determined from the following Table:—

Length	k	Length	k
Metres		Metres	
90	0,788	110	1,231
95	0,894	115	1,351
100	1,003	120	1,476
105	1,115		

Extent of Midship Scantlings

7003 The midship scantlings are to be maintained from 0,2L aft of amidships to 0,2L forward of amidships.

Grades of Steel

7004 Where the thickness of plating exceeds 20,5 mm. and the seams and butts are welded, steel of Grade D (*see* P 2, Table II) will generally be required for the following parts of the structure:—

(*a*) Sheerstrake, strength deck stringer and plating, top strake of the longitudinal bulkhead (where fitted), deck longitudinals of the slab type where cut from plates and through brackets for deck longitudinals from 0,2L aft of amidships to 0,2L forward of amidships, but at least 3 metres forward of the bridge front.

Sheerstrake and strength deck stringer and plating in way of poop front.

Any stringer or sheerstrake plating outside these limits which is above 25,5 mm. in thickness.

(*b*) Bottom shell plating to upper turn of bilge, bottom longitudinals of the slab type where cut from plates and through brackets of bottom longitudinals from 0,15L aft of amidships to 0,15L forward of amidships where the length is 152,4 metres and below, and from 0,25L aft of amidships to 0,2L forward of amidships where the length is 213,4 metres and above with intermediate values obtained by interpolation.

Where the bottom plating is required to be of steel of Grade D the keel is also to be of the same grade.

7005 Strakes of Grade E steel are to be arranged as follows:—

Length L		Grade E strakes
Over	Not Exceeding	
Metres	Metres	
167,6	198,1	Sheerstrake
198,1	—	Sheerstrake
		Bilge Strake

The Grade E strakes are to extend between 0,2L aft of amidships and 0,2L forward of amidships.

The breadth of such strakes is not to be less than 1525 mm. except that the bilge strake shall not be less than 1830 mm.

The use of riveted seams as an alternative to strakes of Grade E steel will be specially considered.

7006 For scantlings and arrangements if higher tensile steel is used *see* D 65, D 66 and D 67.

Double Bottom Structure

7007 The scantlings of the double bottom structure are to be determined in accordance with D 5. Where wing ballast tanks or floodable cofferdams are common with the double bottom tanks, the scantlings of the tank top shall be determined in accordance with 7013 and 7014.

Bottom Shell

7008 The thickness of the bottom shell amidships to upper turn of bilge is to be that necessary to give the required section modulus but is to be not less than:—

(*a*) L = less than 121,9 metres:—

$$\left(\frac{L}{18,6} + 7,62\right) - 0,01\,(915 - s)\text{ mm.}$$

(*b*) L = 121,9 metres and above:—

$$\left(\frac{L}{12,0} + 4,0\right) - 0,01\,(915 - s)\text{ mm.}$$

where L is the length, in metres,

s is the spacing of frames or longitudinals, in mm.

The thickness as determined from these formulæ is applicable to longitudinal framing and where the bottom is transversely framed the thickness is to be increased by 1,5 mm. and, if applicable, the requirements of D 708 are to be complied with.

Side Shell

7009 The thickness of the side shell plating is to be determined from Table 14 and associated notes. If the sides are longitudinally framed, the frame spacing correction is to be based upon the spacing of the longitudinals and the tabular spacing in Column 4 of Table 14.

Transverse Side Framing

7010 The scantlings of transverse side frames are to be obtained from Table 12 and associated notes. Where an inner hull is provided and the side frames are supported by stringers the required section modulus of the frames is:—

$$\frac{I}{y} = \frac{s \times h \times S^2}{107,5}\text{ cm.}^3$$

where s = frame spacing, in mm.,

h = head, in metres, from mid-point of span to deck at side,

S = span, in metres.

Longitudinal Side Framing

7011 The section modulus of side longitudinals is to be not less than:—

$$\frac{I}{y} = \frac{s \times S^2}{117,6}\left(h + \frac{2,5d - D}{6}\right)\text{cm.}^3$$

where s = spacing of longitudinals, in mm.,

S = span, in metres, measured between transverses or from transverse to "span point",

h = distance of longitudinal below deck at side, in metres,

d = summer draught measured from top of keel, but not less than 0,4D, in metres.

7012 Side transverses are to be spaced not more than 3,66 metres apart and the section modulus is to be not less than:—

$$\frac{I}{y} = \frac{s \times h \times S^2}{k}\text{ cm.}^3$$

where s = spacing of transverses, in metres,

S = span of transverses, in metres,

h = head from midpoint of span to deck at side, in metres,

k = $81,6 \times 10^{-3}$ when d/D = 0,75 and above, $94,8 \times 10^{-3}$ when d/D = 0,50 or below, with intermediate values by interpolation.

Inner Hull

7013 Where an inner hull is fitted to form wing ballast tanks (*see* D 7102) the thickness of plating is to be not less than:—

$$t = \left(0,26 + \frac{h}{48,8}\right)\frac{s}{30}\text{mm.}$$

where h = distance, in metres, from lower edge of plate to highest point of tank,

s = spacing of stiffeners, in mm.

7014 The section modulus of horizontal or vertical stiffeners is to be not less than:—

$$\frac{I}{y} = \frac{s \times h \times S^2}{117,6}\text{ cm.}^3$$

where s = spacing, in mm.,

S = span, in metres, measured between girders or from girder to "span point",

h = distance, in metres, from centre of span to highest point of tank, but not less than 1,8 metres.

7015 The width of the wing tank and the spacing of the side transverses are to be such that the transverses, in association with the effective area of shell and bulkhead plating (*see* D 5303), have a section modulus not less than that given by 7012.

Decks

7016 The thickness of deck plating is to be determined from the requirements of 7002 but is to be not less than the minimum thickness as determined from Tables 18 or 20 and associated notes.

7017 The scantlings of beams or longitudinals are to be obtained from Tables 24, 25, 26 or 27 and associated notes as appropriate.

7018 The section modulus of deck transverses is to be not less than:—

$$\frac{I}{y} = \frac{s \times S^2}{13{,}8 \times 10^{-2}} \text{ cm.}^3$$

where s = spacing of transverses, in metres,
S = span of transverses, in metres.

Transverse Bulkheads

7019 The scantlings of single transverse watertight bulkheads are to be determined from Tables 32, 33 and 34 and associated notes.

7020 Where the transverse bulkheads are arranged as floodable cofferdams (*see* D 7105) the scantlings of the bulkheads are to be in accordance with 7013 and 7014.

Cross-references

7021 For filling, discharging and venting pipe arrangements, *see* E 12.

For electrical installations, *see* M 16.

For refrigerating machinery and arrangements, *see* E 12.

For the use of methane gas as fuel for propulsion purposes, *see* R (A).

Section 71

CARRIAGE AT A PRESSURE OF 0,70 kg. per cm.² GAUGE OR LESS

Submission of Plans

7101 In addition to those required by D 108 the following plans are to be submitted:—

Scantlings of cargo tanks.

Details of tank supports and keying arrangements.

Fire extinguishing arrangements.

The following should also be submitted:—

Calculations for dynamic loading of cargo tanks (*see* 7116).

Specification for tank material including results of low temperature tests.

Ship's Structure

7102 Vessels are to have a double bottom and, where the cargo is to be carried at a temperature below —10° C. (+14° F.), are generally to be provided with two longitudinal bulkheads forming side tanks.

7103 Cofferdams are to be arranged at each end of the tank space. Other transverse bulkheads are to be arranged as floodable cofferdams when the minimum cargo temperature is below —50° C. (—58° F.).

7104 When the minimum cargo temperature is below —10° C. (+14° F.) a secondary barrier is to be provided which will act as a temporary containment for the liquefied gas in the event of a leakage from the containers.

Provided the minimum cargo temperature is not below —50° C. (—58° F.) this containment may be provided by the hull structure, but with this arrangement the grades of steel in the containing hull structure are to be dependent on the minimum steel temperatures which may arise in the event of leakage from the cargo tanks, as follows:—

Down to —10° C. (+14° F.) ...	... Grade A
—10° C. (+14° F.) to —30° C. (—22° F.)	... Grade D
—30° C. (—22° F.) to —50° C. (—58° F.)	... Grade E

7105 The insulation arrangements are to be such that the minimum steel temperature in the hull structure adjacent to the cargo tanks does not fall below the following values when the cargo tanks are at the minimum service temperature and the air temperature is 5° C. (+41° F.):—

Grade A ...	0° C. (+32° F.)
Grade D ...	—12° C. (+10° F.)
Grade E ...	—18° C. (0° F.)

7106 Where a secondary barrier separate from the hull structure is provided the following requirements are to be met:—

(*a*) The minimum hull steel temperatures, in the event of leakage from the cargo tanks, shall be not less than those given in 7104 for the particular grade of steel.

(*b*) Thermo-couples are to be arranged on the ship's structure adjacent to the cargo tanks and the

arrangements are to be such as to give continuous temperature readings and audible warning of the development of temperatures lower than given in 7104. In general, such thermo-couples are to be arranged not more than 6,1 metres apart.

(*c*) The extent of the secondary barrier is to be such that the liquefied gas will not come into contact with the hull structure in the event of failure of one cargo tank with the ship heeled to an angle of 30°.

(*d*) The secondary barrier shall be capable of containing the liquefied gas for a period of at least 14 days.

7107 Arrangements are to be provided to enable the double bottom, wing tank spaces and all transverse cofferdams (where fitted) to be flooded in the event of leakage from the cargo tanks.

7108 Suitable arrangements are to be made for sealing the weather deck in way of openings for the cargo tanks.

7109 Any means of access to the spaces around the cargo tanks is to be from above the weather deck.

7110 The spaces containing the cargo tanks are to be permanently filled with an inert gas and a monitoring system is to be installed to ensure that any leakage from the tank is immediately detected.

7111 Arrangements are to be provided to prevent excessive pressure coming on to the containment spaces either during service or in the event of leakage from the cargo tanks.

Cargo Tanks

7112 The material to be used in the construction of the cargo tanks must have suitable mechanical properties at the service temperature. Particulars of the material proposed are to be submitted for approval.

7113 Where a ferritic steel is to be used, tensile, bend and Charpy V-notch impact test pieces are to be prepared from each plate or section. The dimensions of the test pieces are to be in accordance with the requirements contained in P 203, P 204, P 206 and P 207.

The results of the tensile and bend tests are to comply with the approved specification. For the Charpy V-notch impact tests the "required temperature" is the lowest service temperature and the results of the tests are to give an average energy for fracture of not less than 5,53 kg.m.

Other criteria and methods of testing will be accepted where considered equivalent to the above requirements.

7114 It is to be demonstrated by procedure tests that the proposed methods of welding are satisfactory and produce sound welds. Charpy V-notch impact test pieces are to be prepared from butt welded test plates and are to be notched in the heat-affected zone and, if the deposited metal is a ferritic steel, further test pieces are to be notched in the weld. Unless otherwise approved, the results of the impact tests on these test pieces at the minimum temperature of service are to be not less than those specified for the parent material.

7115 For materials other than ferritic steels, the proposed material specification is to be submitted. The notched properties as determined by suitable tests and/or evidence of comparable service experience, at temperatures lower than or equal to the minimum service temperature are also to be submitted, together with corresponding data on the weld metal and heat-affected zone.

7116 The tanks shall be designed to withstand:—

(i) A test head of 2,44 metres of water above the top of the tank or 0,61 metres above the top of the hatch, whichever may be the greater.

(ii) The combined effect of internal vapour pressure (if any) and rolling, pitching and heaving as follows:—

(1) A complete 30° roll port and starboard (i.e. through 120°) in a period of ten seconds.

(2) A pitch of 6° half amplitude in a pitch period of seven seconds (i.e. through 24° in seven seconds).

(3) A heave of L/80 metres half amplitude in a period of eight seconds (i.e. through L/20 metres in eight seconds).

With the loading determined in accordance with the above, the stress in any item shall not exceed three-quarters of the yield stress or three-eighths of the ultimate stress.

7117 Means are to be provided to prevent excessive pressure coming on to the tanks (*see* E 12).

7118 The tanks are to be supported on substantial foundations arranged to avoid excessive concentration of load on the ship's structure or on the tank. Provision is to be made for the thermal contraction of the tanks on cooling from ambient to service temperature and arrangements are to be made to control the movement of the tanks when the vessel is rolling and pitching.

7119 The arrangement of tanks and insulation is to be such that at least one side of the tank plating and adjacent hull structure is readily accessible for inspection.

7120 During the construction of the tanks all butt welds are to be radiographed.

7121 The tanks are to be tested on completion with a head of water in accordance with 7116 (i).

7122 Thermo-couples are to be fitted to at least one tank to enable a satisfactory pre-cooling procedure to be established unless other satisfactory arrangements can be made.

Insulation

7123 The insulation is to be of an approved type and of sufficient thickness to comply with 7105 of these requirements. It is to be suitable for the loads imposed and adequately protected against penetration of water vapour from the atmosphere.

Particulars of the insulating material(s) and the estimated heat conductivity value(s) at the service conditions are to be supplied, together with the proposed thickness(es) and methods of fitting, jointing and sealing the insulation.

Section 72

CARRIAGE AT A PRESSURE ABOVE 0,70 kg. per cm.^{2} GAUGE (WITH OR WITHOUT REFRIGERATION PLANT)

Submission of Plans

7201 In addition to those required by D 108 the following plans are to be submitted:—

Cargo Tank Seatings and Securing Arrangements.
Hold Ventilation System.
Fire Extinguishing Arrangements.

Ship's Structure

7202 Where the cargo is to be carried at a temperature below ambient the requirements of D 7104 and D 7105 are to be complied with.

7203 Cofferdams, or single bulkheads of all-welded construction forming an "A" class fire-resisting division, are to be arranged between spaces containing the cargo tanks and machinery spaces.

Installation of Cargo Tanks

7204 Cargo tanks are to be sited so that the following minimum clearances are obtained:—

(*a*) Tanks to the side shell—generally 610 mm., but clearances at the ends of the ship below the load waterline will be specially considered.

(*b*) Tanks to inner bottom plating—150 mm.

(*c*) Tanks to bottom shell (if no inner bottom is fitted)—the dimension given in Table 6, Col. 4 (without correction for draught).

Where more than one tank is fitted in a space, sufficient clearance is to be left between tanks for inspection or repairs and in no case less than 300 mm.

7205 Cargo tank seatings and securing arrangements are to be suitable for dynamic loading to the extent given in D 7116 and should also be suitable for the forces arising when a cargo hold is flooded with the cargo tanks empty. Seatings are to be designed to ensure uniform support to the pressure vessel having due regard to deflections of the hull structure in a seaway. When the cargo is to be carried at temperatures below ambient, provision is to be made for expansion and contraction.

7206 The supports and securing arrangements should also be capable of withstanding a longitudinal acceleration of 0,5 g.

7207 Suitable arrangements are to be made for sealing the weather deck in way of openings for the cargo tanks.

7208 The spaces containing the cargo tanks are to be provided with means for access from above the weather deck.

7209 Ventilation systems for the spaces containing cargo tanks are to be independent of other ventilation systems, and means are to be provided to enable any single compartment to be isolated. Details, including the positioning of exhaust outlets, are to be submitted.

7210 Means are to be provided to enable the air in the cargo tank spaces, pump and compressor rooms to be sampled to detect any leakage.

Cross-reference

7211 For cargo tanks and their mountings *see* J 25 and E 12.

21st May, 1964

Chapter E

PUMPING AND PIPING

Section 1

PLANS

101 The following plans are to be submitted for consideration:—

General pumping arrangements, including air and sounding pipes and any cross flooding pipes and fittings. (Shipbuilder's plan.)

Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.

General arrangement of cargo piping in tanks and on deck of oil tankers.

Piping arrangements for cargo oil (F.P. above 65,5° C.).

Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service. In the case of passenger ships the criterion numeral, as defined in the International Convention for the Safety of Life at Sea–1960 is to be stated together with the number of flooded compartments which the ship is required to withstand under damage conditions.

Arrangement of oil fuel pipes and fittings at settling and service tanks.

Arrangements of oil fuel piping in connection with oil burning installations and oil fired galleys.

Oil fuel and cargo oil overflow systems, where these are fitted.

Arrangement of boiler feed system.

Arrangement of compressed air systems for main and auxiliary essential services.

Arrangement of cooling water systems for main and auxiliary essential services.

Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.

Above plans of machinery space piping are to be diagrammatic.

Arrangement and dimensions of main steam pipes with details of flanges, bolts and weld attachments and particulars of the material of pipes, flanges bolts and electrodes.

NOTE.—Plans additional to the above should not be submitted unless the arrangements are of a novel or special character affecting classification.

See G 111 for centralised or automatic controls to tanker pumping systems.

See Chapter R(D) for Guidance Notes on Metal Pipes for Water Services.

Section 2

GENERAL

201 In power driven ships the pumping arrangements according to the division of compartments, rise of floor and other conditions are to be as detailed in these Rules which apply to passenger ships, cargo and other ships except where otherwise stated.

202 While the arrangements satisfy the requirements of the International Convention for the Safety of Life at Sea–1960, attention should be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

203 The Committee will be prepared to give consideration to special cases or to arrangements which are fully equivalent to those required by these Rules. Consideration will also be given to the pumping arrangements of small ships and ships to be assigned class notations for restricted or special services.

(For pumping arrangements of non-propelled ships, *see* E 10.)

BILGE AND BALLAST

204 All ships are to be provided with efficient pumping plant having the suctions and means for drainage so arranged that any water within any compartment of the ship, or any watertight section of any compartment, can be pumped out through at least one suction when the ship is on an even keel and is either upright or has a list of not more than 5 degrees. For this purpose wing suctions will generally be necessary, except in short, narrow compartments where one suction can provide effective drainage under the above conditions.

In passenger ships the pumping plant is to be capable of draining any watertight compartment under all practical conditions after a casualty, whether the ship is upright or listed.

Hold Drainage

205 In ships having only one hold, and this over 33,5 metres in length, bilge suctions are to be fitted in suitable positions in the after half-length, also in the forward half-length of the hold.

206 Where close ceiling or continuous gusset plates are fitted over the bilges, arrangements are to be made whereby water in a hold compartment may find its way to the suction pipes.

207 Where the inner bottom plating extends to the ship's side, the bilge suctions are to be led to wells placed at the wings. If the tank top plating has inverse camber, a well is also to be fitted at the centre line.

Bilge wells are to be formed of steel plates and are to be of not less than 0,17 cubic metre capacity. In small compartments, steel bilge hats of reasonable capacity may be fitted.

In passenger ships wells in double bottom tanks are not to extend downwards more than necessary; the depth of the well is in no case to be more than the depth less 460 mm. of the double bottom at the centre line, nor shall the well extend below the horizontal plane referred to in D 526.

Where access manholes to bilge wells are necessary, they are to be fitted as near to the suction strums as practicable.

208 Access to the bilge suction strum of a hold well should not be obtained by means of a manhole in the machinery space watertight bulkheads or tank top plating in the machinery space or tunnel if this can be avoided.

Where, however, this arrangement is necessary, the watertight manhole cover should be of hinged type and an instruction plate, in raised letters, should be affixed in a well lighted position, to the effect that this door must be kept shut, except when access is required. In passenger ships these arrangements are not permissible.

209 The intactness of the machinery space bulkheads, and of tunnel plating which is required to be of watertight construction, is not to be impaired by the fitting of scuppers discharging to machinery space or tunnels from adjacent compartments which are situated below the bulkhead deck.

These scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

The tank air pipe is to be led to above the bulkhead deck and provision is to be made for ascertaining the level of water in the tank.

Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non-return valves.

210 Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage either by hand or power pump bilge suctions.

If, however, these compartments are adequately isolated from the adjacent 'tween decks, they may be drained by scuppers not less than 38 mm. bore, discharging to the tunnel and fitted with self-closing cocks situated in well lighted and visible positions. These arrangements are not applicable to passenger ships unless specially approved in relation to sub-division considerations.

Drainage from Refrigerated Cargo Spaces

211 Provision is to be made for the continuous drainage of the inside of all insulated chambers and cooler trays.

212 Drains which are led from lower holds and cooler trays situated on the tank top are to be fitted with liquid sealed non-return bilge traps.

Drains from 'tween deck chambers and from cooler trays which are situated well above the tank top are also to be fitted with liquid sealed traps, but the non-return valves may be omitted if desired. (For insulation of scupper pipes, *see* E 418.)

213 Where drains from separate chambers join a common main, the branch pipes are each to be provided with a liquid sealed trap.

214 The liquid sealed traps are to be of adequate depth and arrangements are to be made for ready access to the traps for cleaning and refilling with brine.

215 Sluices, scuppers or drain pipes which would permit drainage from compartments outside the insulated chambers into the bilges of the latter are not to be fitted.

216 Screwed plugs or other means for blanking off scuppers draining insulating chambers and cooler trays are not to be fitted.

If, however, it is specially desired by the Owners to provide means for temporarily closing these scuppers, they may be fitted with shut-off valves controlled from readily accessible positions on a deck above the load water line.

Machinery Space—Bilge Drainage

217 The bilge drainage arrangements in the machinery space are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions when the ship is on an even keel and is either upright or has a list of not more than 5 degrees. One of

these suctions is to be a branch bilge suction, i.e., a suction connected to the main bilge line, and the other is to be led direct from an independent power pump. Examples of the necessary arrangements are detailed in 218 to 220.

In passenger ships the drainage arrangements are to be such that machinery spaces can be pumped out under all practical conditions after a casualty whether the ship is upright or listed.

218 Where the double bottom extends the full length of the machinery space and forms bilges at the wings, it will be necessary to provide one branch and one direct bilge suction at each side.

219 Where the double bottom plating extends the full length and breadth of the compartment, one branch bilge suction and one direct bilge suction are to be led to each of two bilge wells of not less than 0,17 cubic metre capacity, situated one at each side.

In passenger ships the depth of bilge wells is to comply with the requirements of 207.

220 Where there is no double bottom and the rise of floor is not less than 5 degrees, one branch and one direct bilge suction are to be led to accessible positions as near the centre line as practicable.

In ships where the rise of floor is less than 5 degrees and in all passenger ships additional bilge suctions are to be provided at the wings.

221 Additional bilge suctions may be required for the drainage of depressions in the tank top formed by crank pits, or other recesses, by tank tops having inverse camber or by discontinuity of the double bottom.

222 In ships in which the propelling machinery is situated at the after end of the ship, it will generally be necessary for bilge suctions to be fitted in the forward wings as well as the after end of the machinery space, but each case will be dealt with according to the size and structural arrangements of the compartment.

223 In ships propelled by electrical machinery, special means are to be provided to prevent the accumulation of bilge water under the main propulsion generators and motors.

224 Where the machinery space is divided by watertight bulkheads to separate the boiler room(s) or auxiliary engine room(s) from the main engine room, the number and position of the branch bilge suctions in the boiler room(s) and auxiliary engine room(s) are to be the same as for cargo holds.

In addition to the branch bilge suctions an independent power pump direct bilge suction is to be fitted in each compartment. Similar provision is to be made in separate motor rooms of electrically propelled ships.

225 In passenger ships each independent bilge pump is to have a direct bilge suction from the space in which it is situated, but not more than two such suctions are required in any one space. Where two or more such suctions are provided there is to be at least one suction on each side of the space.

Machinery Space—Emergency Bilge Drainage

226 In steamers, the main circulating water pump to each main engine is to be fitted with an emergency bilge suction, i.e., "bilge injection", which is to be additional to the bilge suctions detailed in 217 to 225. This suction, which is to have a diameter of at least two-thirds that of the pump suction, is to be led to a suitable low level in the machinery space and is to be fitted with a screw-down non-return valve having the spindle so extended that the hand-wheel is not less than 457 mm. above the bottom platform.

If two pumps are provided for one engine, each capable of supplying sufficient cooling water for normal power, only one pump need be fitted with an emergency bilge suction.

In coal-burning steamships a flexible bilge hose is to be provided for connecting to the independent power bilge pump. The hose is to have an internal diameter of 102 mm. or that required for the main bilge line, whichever is the less, and is to be of sufficient length to reach any part of the engine and boiler room bilges into which coal or ashes could be washed. The lower end of the hose is to be provided with a strainer.

The hose fitting on the pump is to comply with the requirements of 246.

Where main circulating water pumps are not suitable for bilge pumping duties, alternative arrangements may be submitted for consideration.

227 In motorships, the emergency bilge suction is to be led to the main cooling water pump or to the main cooling water suction line. The suction is to be of the same size as the suction branch of the cooling water pump and the valve nameplate is to be marked "For emergency use only".

Alternatively, the emergency bilge suction may be led to the largest available power pump which is not fitted with a direct bilge suction and is to be of the same size as the suction branch of the pump. This pump is to have a capacity greater than that required for a bilge pump, and if it is of the self-priming type the direct bilge suction on the same side of the ship as the emergency suction may be omitted, except in passenger ships.

Tunnel Drainage

228 The tunnel well is to be drained by a suction from the main bilge line. In all ships including passenger ships this well may extend to the outer bottom.

229 Where the tank top in the tunnel slopes down from aft to forward, a bilge suction is to be provided at the forward end of the tunnel, in addition to the tunnel well suction required by 228.

Sizes of Bilge Suction Pipes

230 The diameters of bilge suction pipes are to be not less than required by the following formulæ, to the nearest 5 mm.:—

MAIN BILGE LINE

$$d_m = 26 + \sqrt{2{,}78\,L\,(B + D)} \qquad (a)$$

In no case is the diameter of the main bilge line to be less than required for any branch bilge suction.

BRANCH BILGE SUCTIONS TO CARGO AND MACHINERY SPACES

$$d_b = 26 + \sqrt{4{,}63\,C\,(B + D)} \qquad (b)$$

where d_m = internal diameter of main bilge line, in millimetres,

d_b = internal diameter of branch bilge suction, in millimetres,

L = Rule length of ship, in metres,

B = Rule breadth of ship, in metres,

D = moulded depth to bulkhead deck, in metres,

C = length of compartment, in metres.

No bilge suction pipe is, however, to be less than 50 mm. bore.

DIRECT BILGE SUCTIONS, OTHER THAN EMERGENCY SUCTIONS

231 The direct bilge suctions in the main engine room and the direct bilge suctions in large separate boiler rooms, motor rooms of electrically propelled ships and auxiliary engine rooms are to be of a diameter not less than required for the main bilge line.

Where the separate machinery spaces are of small dimensions, the sizes of the direct bilge suctions to these spaces will be specially considered.

For sizes of emergency bilge suctions, *see* 226 and 227.

232 In oil tankers and similar ships where the engine room pumps do not deal with bilge drainage outside the machinery space, the diameter of the main bilge line may be less than required by 230, formula (*a*), provided the cross-sectional area is not less than twice that required for the branch bilge suctions in the machinery space.

233 The area of each branch pipe connecting the bilge main to a bilge distribution chest is to be not less than the sum of the areas required by the Rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

234 The bilge suction pipe to the tunnel well is to be not less than 65 mm. bore, except in ships not exceeding 61 metres in length, in which case it may be 50 mm. bore.

Bilge and General Service Pumps

235 For ships other than passenger ships at least two power bilge pumping units are to be provided in the machinery space. In ships of 91,5 metres in length and under, one of these units may be worked from the main engines and the other is to be independently driven. In larger ships both units are to be independently driven.

Each of these units is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of bilge line of not less than 122 metres per minute under ordinary working conditions, but where one unit is of slightly less than this capacity, the deficiency may be made good by an excess capacity of the other unit.

236 TABLE OF CAPACITIES

Bore of bilge pipe		Capacity of each pumping unit in metres³/hour	Bore of bilge pipe		Capacity of each pumping unit in metres³/hour
Ins.	Metric equivalent in mm.		Ins.	Metric equivalent in mm.	
2	51	15	$5\frac{1}{4}$	133	103
$2\frac{1}{4}$	57	19	$5\frac{1}{2}$	140	113
$2\frac{1}{2}$	63,5	23	$5\frac{3}{4}$	146	124
$2\frac{3}{4}$	70	28	6	152	135
3	76	34	$6\frac{1}{4}$	159	146
$3\frac{1}{4}$	82,5	40	$6\frac{1}{2}$	165	158
$3\frac{1}{2}$	89	46	$6\frac{3}{4}$	171	171
$3\frac{3}{4}$	95	53	7	178	183
4	102	60	$7\frac{1}{4}$	184	197
$4\frac{1}{4}$	108	68	$7\frac{1}{2}$	190	210
$4\frac{1}{2}$	114	76	$7\frac{3}{4}$	197	224
$4\frac{3}{4}$	121	84	8	203	239
5	127	93	$8\frac{1}{4}$	209	254

237 Each unit may consist of one or more pumps connected to the main bilge line, provided their combined capacity is adequate.

238 In ships other than passenger ships a bilge ejector in combination with a high pressure sea water pump may be accepted as a substitute for an independent bilge pump required by 235.

239 For passenger ships at least three power bilge pumps are to be provided, one of which may be operated from the main engines. Where the criterion numeral is 30 or more, one additional independent power pump is to be provided. A main engine driven pump may be replaced by an independent pump. Each pump is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of main bilge pipe of not less than 122 metres per minute.

For location of pumps, *see* 256.

Self-Priming Pumps

240 All power pumps which are essential for bilge services are to be of self-priming type, unless an approved central priming system is provided for these pumps. Details of this system are to be submitted.

Cooling water pumps having bilge ejection connections need not be of self-priming type.

Pump Connections

241 The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

242 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any of the pumps so connected is unaffected by the other pumps being in operation at the same time.

Direct Bilge Suctions

243 The direct bilge suctions in the machinery space(s) are to be led to independent power pump(s), and the arrangements are to be such that these direct suctions can be used independently of the main bilge line suctions.

Main Bilge Line Suctions

244 Suctions from the main bilge line, i.e., branch bilge suctions, are to be arranged to draw water from any hold or machinery compartment of the ship, excepting small spaces such as those mentioned in 262, where manual pump suctions are accepted, and are to be of not less size than required by 230, formula (*b*). (For special arrangements for oil tankers, *see* E 1112 to E 1117).

Pipe Systems and their Fittings

245 The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks.

To effect this requirement, the bilge connections to any pump having also suctions from the sea and from tanks should be made either by means of non-return valves or cocks which cannot permit communication between the bilges and the sea or compartments in use as tanks.

246 Screw-down non-return valves are to be provided in the following fittings:—

Bilge valve distribution chests;

Bilge suction hose connections, whether fitted direct to the pump or on the main bilge line;

Direct bilge suctions and bilge pump connections to main bilge line.

247 Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to either a bilge, ballast or oil line.

248 Suctions for bilge drainage in machinery spaces and tunnels, other than emergency suctions, are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges and having covers secured in such a manner as to permit of their being expeditiously opened or closed. Strum boxes are not to be fitted to the lower ends of these tail pipes.

249 The open ends of bilge suctions in holds and other compartments outside machinery spaces and tunnels, are to be enclosed in strum boxes having perforations not more than 10 mm. diameter, whose combined area is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

The distance between the foot of all bilge tail pipes and the bottom of the bilge or well is to be adequate to allow a full flow of water and to facilitate cleaning.

250 All cocks and valves in connection with bilge, ballast and fresh water suction pipes are to be fitted with legible nameplates, and, unless otherwise specifically mentioned in the Rules, are to be fitted in places where they are at all times readily accessible.

251 Bilge cocks, valves and mud boxes are to be fitted at, or above, the machinery space and tunnel platforms.

Where it is not practicable to avoid the fittings being situated at the starting platform or in passageways, they may be situated just below the platform, provided readily removable traps or covers are fitted and nameplates indicate the presence of these fittings.

If relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform.

252 Bilge suction pipes are not to be carried through double bottom tanks if it is possible to avoid doing so.

Bilge pipes which pass through these tanks are to be of substantial strength and are to be tested, after fitting, to the same pressure as the tanks through which they pass.

253 In way of deep tanks for water ballast, fresh water, oil fuel or cargo oil, bilge pipes should preferably be led through pipe tunnels but, where this is not done, the pipes are to be of steel of heavy gauge with welded joints or heavy flanged joints. The number of joints is to be kept to a minimum.

Expansion bends, not glands, are to be fitted to these pipes within the tanks, and the open ends of the bilge suction pipes in the holds are to be fitted with non-return valves of the special type approved for use in holds (*see* 266).

Tank piping, other than that of the deep cargo tank pumping system, is not to be situated within deep cargo oil tanks.

The pipes are to be tested, after fitting, to a pressure not less than the maximum head to which the tanks can be subjected.

254 Bilge, ballast and cooling water suction and discharge pipes are to be permanent pipes made in readily removable lengths with flanged joints, except as mentioned in 253, and are to be efficiently secured in position to prevent chafing or lateral movement.

Long or heavy lengths of pipes are to be supported by bearers so that no undue load is carried by the flanged connections of the pumps or fittings to which they are attached.

Where lack of space prevents the use of normal circular flanges, details of the alternative methods of joining the pipes are to be submitted.

Pipes for the bilge and ballast systems are to be made of cast or wrought iron, steel, copper or other approved material. Heat sensitive materials such as lead are not to be used.

255 Suitable provision for expansion is to be made in each range of pipes.

Bilge Drainage and Cross Flooding Arrangements for Passenger Ships in Damaged Condition

256 In passenger ships the power bilge pumps are, if practicable, to be placed in separate watertight compartments which will not readily be flooded by the same damage. If the engines and boilers are in two or more watertight compartments, the bilge pumps are to be distributed throughout these compartments as far as possible.

In passenger ships of 91,5 metres or more in length or having a criterion numeral of 30 or more, the arrangements are to be such that at least one power pump will be available for use in all ordinary circumstances in which the ship may be flooded at sea. This requirement will be satisfied if:—

(*a*) One of the pumps is an emergency pump of a submersible type having a source of power situated above the bulkhead deck or,

(*b*) The pumps and their sources of power are so disposed throughout the length of the ship that, under any conditions of flooding which the ship is required by statutory regulation to withstand, at least one pump in an undamaged compartment will be available.

257 The bilge main is to be arranged so that no part is situated nearer the side of the ship than $\frac{B}{5}$ where B is the breadth of the ship.

Where any bilge pump or its pipe connection to the bilge main is situated outboard of the $\frac{B}{5}$ line then a non-return valve is to be provided in the pipe connection at the junction with the bilge main. The emergency bilge pump and its connections to the bilge main are to be arranged so that they are situated inboard of the $\frac{B}{5}$ line.

258 Provision is to be made to prevent the compartment served by any bilge suction pipe being flooded in the event of the pipe being severed, or otherwise damaged by collision or grounding in any other compartment. For this purpose, where the pipe is at any part situated nearer the side of the ship than $\frac{B}{5}$ or in a duct keel, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

259 All the distribution boxes, cocks and valves in connection with the bilge pumping arrangements are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative on any compartment. If there is only one system of pipes common to all pumps, the necessary cocks or valves for controlling the bilge suctions must be capable of being operated from above the bulkhead deck. Where in addition to the main bilge pumping system an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating on any compartment under flooding conditions; in this case only the cocks and valves necessary for the operation of the emergency system need be capable of being operated from above the bulkhead deck.

260 All cocks and valves mentioned in the foregoing paragraphs which can be operated from above the bulkhead deck are to have their controls at their place of operation clearly marked and provided with means to indicate whether they are open or closed.

261 Where divided deep tanks or side tanks are provided with cross flooding arrangements to limit the angle of heel after side damage, the arrangements are either to be self acting or controlled from above the bulkhead deck.

Fore and After Peak Drainage

262 Where the peaks are used as tanks, a power pump suction is to be led to each tank, except in the case of small tanks used for the carriage of domestic fresh water, when hand pumps may be used.

The collision bulkhead is not to be pierced below the bulkhead deck in passenger and cargo ships by more than two pipes. The pipes are to be provided with screw-down valves capable of being operated from an accessible position above the bulkhead deck, the chests being secured to the bulkhead inside the fore peak. Indicators are to be provided to show whether the valves are open or shut.

Where the peaks are not used as tanks and main bilge line suctions are not fitted, drainage of both peaks may be effected by hand pump suctions, provided the suction lift be well within the capacity of the pumps and in no case exceeds 7,3 metres.

Provision is to be made for the drainage of the chain locker and the watertight flat above the fore peak tank by hand or power pump suction. (For drainage of the flat above the after peak tank, *see* 210).

Watertight Bulkhead and Tunnel Fittings

263 No drain valve or cock is to be fitted to the collision bulkhead.

Drain valves or cocks are not to be fitted to other watertight bulkheads, if alternative means of drainage are practicable.

Where fitted, the valves and cocks are to be at all times readily accessible and are to be capable of being shut off from positions above the bulkhead deck. Indicators are to be provided to show whether the drains are open or shut. These arrangements are not permissible in passenger ships. (For drainage of stern compartments, *see* 210.)

264 Valve chests, cocks, pipes or other fittings attached direct to the plating of tanks, and to bulkheads, flats or tunnels which are required to be of watertight construction, are to be secured by means of studs screwed through the plating or by tap bolts and not by bolts passing through clearance holes.

Alternatively, the studs or the bulkhead piece may be welded to the plating.

Deep Tanks

265 In the case of deep tanks which may be used for either water ballast or dry cargo, provision is to be made for blank flanging the water ballast filling and suction pipes when the tank is being used for the carriage of dry cargo and for blank flanging the bilge suction pipes when the tank is being used for the carriage of water ballast.

Change-over devices may be used for this purpose. (For arrangements when oil fuel or cargo oil is carried in deep tanks, *see* E 324.)

Hold Bilge Valves

266 Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

Ship Side Valves (other than those on Scuppers and Sanitary Discharges)

267 All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell plating or to the plating of fabricated steel water boxes attached to the shell plating. These fittings are to be secured by bolts tapped into the plating and fitted with countersunk heads or by studs screwed into heavy steel pads fitted to the plating. The stud holes are not to penetrate the plating.

Distance pieces of short rigid construction, and made of approved material as required by 270, may be fitted between the valves and shell plating. Distance pieces of steel may be welded to the shell plating. Details of the welded connections and of fabricated steel water boxes are to be submitted.

Gratings are to be fitted at all openings in the ship's side for sea inlet valves and inlet water boxes. The net area through the gratings is to be not less than twice that of the valves connected to the sea inlets and provision is to be made for clearing the gratings. (*See* 271.)

268 All suction and discharge valves and cocks direct on the shell plating of the ship are to be fitted with spigots passing through the plating, but the spigots on the valves or cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the shell plating.

Blow-down cocks or valves are also to be fitted with a protection ring through which the spigot is to pass, the ring being on the outside of the shell plating.

Blow-down cocks or valves on the ship's side are to be fitted in accessible positions above the level of the working platform and are to be arranged so that it can be readily seen whether they are open or shut. Cock handles are not to be capable of being removed unless the cocks are shut, and if valves are fitted, the wheels are to be fixed to the spindles.

269 Sea inlet and overboard discharge cocks and valves are in all cases to be fitted in easily accessible positions and, as far as practicable, are to be readily visible.

Provision is to be made for preventing any discharge of water into lifeboats.

The inlet valve spindles are to extend above the lower platform, and the hand wheels of the main injection and bilge injection valves are to be situated not less than 460 mm. above this platform.

270 Where valves or cocks are over 75 mm. bore, they are to be of steel or an approved grade of cast iron or other approved material; this requirement applies equally to inlet chests, distance pieces, and other sea connections.

All these fittings, if made of steel, are to be suitably protected against wastage.

271 The scantlings of valves and valve stools fitted with steam or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

Cross-reference

272 For sea connections for ships having notation for ice navigation, *see* H 808 to H 810.

Miscellaneous Requirements

273 All pipes situated in cargo spaces, coal bunkers, chain lockers or other positions where they are liable to mechanical damage are to be efficiently protected. (*See* D 2519, quoted at end of this Section, and D 2412, quoted at end of E 4.)

274 Wash deck pipes and discharge pipes from the pumps to domestic water tanks are not to be led through cargo holds if, as is generally the case, it is practicable to avoid doing so. Any proposed departure from this requirement is to be submitted.

275 As far as practicable, pipe lines, including exhaust pipes from oil engines, are not to be led in the vicinity of switchboards or other electrical appliances in positions where drip or escape of liquid, gas or steam from joints or fittings may cause damage to the electrical installation.

Where it is not practicable to comply with these requirements, drip trays or shields are to be provided as found necessary.

Short sounding pipes to tanks should not terminate near electrical appliances (*see* E 413).

Extract from Chapter D for reference

Scuppers

D 2508 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

D 2509 When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

D 2510 Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

D 2511 Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screwdown non-return valves as required by 2510.

D 2512 Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

D 2513 Scuppers which drain overboard from spaces referred to in 2511 and 2512 and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

D 2514 Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

D 2515 Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

Sanitary Discharges

D 2516 Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down automatic non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

D 2517 Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in 2516 may be required.

Materials for Valves and Pipes

D 2518 Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality. (*See also* F706).

Protection of Pipes and Valves

D 2519 In all cargo spaces or coal bunkers scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

Section 3

OIL FUEL AND CARGO OILS HAVING A FLASH POINT ABOVE 65,5° C.

General

301 In addition to the special requirements detailed in this Section, the requirements of E 2 relating to bilge and ballast are to be complied with in so far as they are applicable to the drainage of tanks, oil bilges and cofferdams.

302 The flash point (closed test) of oil fuel for use in steam and motor ships classed for unrestricted service is in general not to be less than 65,5° C. For emergency generator engines a flash point of not less than 43° C. is permissible.

Fuels with flash points lower than 65,5° C. may be used in ships intended for service restricted to geographical limits where it can be ensured that the temperature of the machinery and boiler spaces will always be 16,5° C. below the flash point of the fuel. In such cases, safety precautions and the arrangements for storage and pumping will be specially considered. However, the flash point of the fuel is to be not less than 54° C. when supplied for oil fired boilers or 43° C. for oil engines unless specially approved.

When it is desired to carry a quantity of fuel having a flash point below 43° C. for special services, e.g. aviation spirit for use in helicopters, full particulars of the proposed arrangements are to be submitted for special consideration. For the burning of methane gas in methane tankers *see* Chapter R(A).

Oil Fuel Pumps and Oil Burning Appliances

303 In every ship where steam for the main propelling engines, or for auxiliary machinery which is required for essential services, is generated by burning oil fuel under pressure, there are to be not less than two oil burning units, each unit comprising a pressure pump, a suction filter, a discharge filter and a heater.

In two unit installations, each unit is to be capable of supplying fuel for generating all the steam required for essential services.

In installations of three or more units, the capacities and arrangements of the units are to be such that all the steam required for essential services can be maintained with any one unit out of action.

304 Unit pressure pumps for the oil burning system are to be entirely separate from the feed, bilge or ballast systems.

305 In systems where oil is fed to the burners by gravity, duplex filters are to be fitted in the supply pipe line to the burners and so arranged that one filter can be opened up when the other is in use. Similar or equivalent arrangements are to be provided in the fuel supply lines to main and auxiliary oil engines and gas turbines.

306 If oil fuel is sprayed by steam, means are to be provided to carry or make up the fresh water used for this purpose.

307 A starting-up oil fuel unit, including an auxiliary heater and hand pump, or other suitable starting-up device, which does not require power from shore, is to be provided.

Alternatively, where auxiliary machinery requiring compressed air or electric power is used to bring the boiler plant into operation, the arrangements for starting such machinery are to comply with H 708.

308 All pumps used in connection with oil fuel are to be provided with effective escape valves which are to be in close circuit, i.e., discharging back to the suction side of the pumps.

Escape valves are also to be fitted on the oil side of the heaters, discharging to the pump suction line, to the tray under the unit, or to other approved position, and are to be adjusted to operate at a pressure of 3,5 kg. per cm.^{2} above that of the pump escape valve.

309 Where a power driven transfer pump is necessary for pumping up the settling tanks in motorships and steamships, a stand-by pump is to be provided and connected ready for use, or alternatively, emergency connections may be made to one of the unit pumps or to another suitable power driven pump.

Oil Pipes and Fittings

310 Pipes conveying heated oil under pressure are to be of seamless steel or other approved material having flanged couplings and placed in sight above the platform in well lighted parts of the stokehold or engine room.

The flanges are to be machined and the jointing material, which is to be impervious to oil heated to 150° C., is to be the thinnest possible, so that the flanges are practically metal to metal. The scantlings of the pipes and their flanges are to be suitable for at least 14 kg. per cm.^{2} working pressure, or the pressure to which the relief valves are adjusted, whichever is the greater.

The piping system is to be tested after jointing to twice the working pressure.

The thickness of the oil fuel pressure pipes is to be determined from the formula contained in E 512.

311 The short joining lengths of pipes to the burners from the control valves on the boiler front may have cone unions of specially robust construction.

Flexible pipes of approved material and design may be used for the burner pipes provided spare lengths, complete with couplings, be carried on board.

A quick closing master valve is to be fitted on the hot oil supply to each boiler manifold.

312 Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be made of cast or wrought iron or steel, having flanged joints suitable for a working pressure of not less than 7 kg. per cm.^{2}. The flanges are to be machined and the jointing material is to be impervious to oil. Where the pipes are 25 mm. bore, or less, they may be of seamless copper or copper alloy excepting those which pass through oil storage tanks. Oil pipes within the engine and boiler spaces are to be fitted where they can be readily inspected and repaired, and after jointing they are to be tested to 3,5 kg. per cm^2, or twice the maximum working pressure, whichever is the greater.

Valves and Cocks

313 The valves, cocks and their pipe connections are to be so arranged that oil cannot be admitted into tanks which are not structurally suitable for the carriage of oil or into tanks which can be used for the carriage of fresh water intended for boiler feed or for drinking.

In passenger ships provision is to be made for the transfer of oil fuel from any oil fuel storage or settling tank to any other oil fuel storage or settling tank in the event of fire or damage.

314 Every oil fuel suction pipe from a double bottom tank is to be fitted with a valve or cock.

315 Every oil fuel suction pipe from a storage, settling and daily service tank situated above the double bottom and every oil fuel levelling pipe within the boiler room or engine room is to be fitted with a valve or cock secured to the tank. In the case of fore peak tanks, these valves are to be fitted on the tank side of the bulkhead.

In the engine and boiler spaces, such valves and cocks are to be capable of being closed locally and from positions which will always be accessible in the event of fire taking place in these spaces. Indicators are to be provided at the valves and cocks and at the remote control positions to show whether they are open or shut.

In the case of very small tanks consideration will be given to the omission of remote controls.

316 Every oil fuel suction pipe which is led into the engine and boiler spaces from a tank situated above the double bottom outside these spaces is to be fitted in the machinery space with a remote controlled valve, except where the valve on the tank is already remote controlled.

317 All valves and cocks forming part of the oil fuel installation are to be capable of being controlled from readily accessible positions which, in the engine and boiler spaces, are to be above the working platform.

Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

Oil fuel valves are to be so constructed as to prevent the possibility of any cover being slacked back or loosened when operating the valves. The valves and cocks are to be fitted with legible nameplates.

318 Where the filling pipes to deep oil tanks are not connected to the tanks near the top, they are to be provided with non-return valves at the tanks or with valves or cocks fitted and controlled as in the case of the outlet valves or cocks on these tanks.

319 Open drains for removing the water from oil tanks are to be fitted with cocks or valves of self-closing type and suitable provision is to be made for collecting the oily discharge.

Oil Fired Galleys

320 The fuel oil tank is to be located outside the galley and is to be fitted with approved means of filling and venting. The fuel supply to the burners is to be controlled from a position which will always be accessible in the event of a fire occuring in the galley. The galley is to be well ventilated.

When liquefied petroleum gas is used similar provisions are to be made.

Filling Arrangements

321 In passenger ships, the filling station is to be isolated from other spaces and is to be efficiently drained and ventilated. Provision is to be made against over-pressure in the filling pipe lines and any relief valve fitted for this purpose is to discharge to an overflow tank or other safe position.

Alternative Carriage of Oil Fuel and Water Ballast

322 Where it is intended to carry oil fuel and water ballast in the same compartments alternatively, the valves or cocks connecting the suction pipes of these compartments with the ballast pump and those connecting them with the oil fuel transfer pump are to be so arranged that the oil may be pumped from any one compartment by the oil fuel pump at the same time as the ballast pump is being used on any other compartment.

Where settling or service tanks are fitted each having a capacity sufficient to permit of 12 hours' normal service without replenishment, the above requirement may be dispensed with.

323 Attention is drawn to the statutory regulations issued by National Authorities in connection with the International Convention for Prevention of Pollution of the Sea by Oil, 1954.

Deep Tanks for the Alternative Carriage of Oil, Water Ballast or Dry Cargo

324 In the case of deep tanks which can be used for the carriage of oil fuel, cargo oil, water ballast or dry cargo, provision is to be made for blank flanging the oil and water ballast filling and suction pipes, also the steam heating coils if retained in place, when the tank is used for dry cargo and for blank flanging the bilge suction pipes when the tanks are used for oil or water ballast.

If the deep tanks are connected to an overflow system the arrangements are to be such that liquid or vapour from other tanks cannot enter the deep tanks when dry cargo is carried in them.

Oily Bilge Drainage and Sediment Suctions

325 Provision is to be made for the drainage of oil gutterways, oil wells and cofferdams. (*See* D 2024 to D 2028, quoted at end of this Section.)

Fresh Water Piping

326 Pipes in connection with compartments used for storing boiler feed water are to be separate and distinct from any pipes which may be used for oil or oily water, and are not to be led through tanks which contain oil, nor are oil pipes to be led through boiler feed water tanks.

Similar precautions are necessary when the connections are such that fresh water carried in other tanks can be used as reserve feed water.

Service, Settling and other Oil Fuel Tanks

327 In general, the minimum thickness of the plating of these tanks, when they do not form part of the structure of the ship, is to be 5 mm., but in the case of very small tanks, the minumum thickness may be 3 mm.

For rectangular steel tanks of welded construction the plate thicknesses are to be not less than indicated in the following Table. The stiffeners are to be of approved dimensions.

Thickness of Plate (mm.)	Head from Bottom of Tank to Top of Overflow Pipe (Metres)				
	2,5	3,0	3,7	4,3	4,9
	Breadth of Panel (mm.)				
5	585	525			
6	725	645	590		
7	860	770	700	650	
8	1000	900	820	750	700
10	1280	1140	1040	960	900

The dimension given in the Table for the breadth of the panel is the maximum distance allowable between continuous lines of support, which may be stiffeners, washplates or the boundary plating of the tank.

Where necessary, stiffeners are to be provided and if the length of the stiffener exceeds twice the breadth of the panel, transverse stiffeners are also to be fitted, or, alternatively, tie bars are to be provided between stiffeners on opposite sides of the tank.

On completion the tanks are to be tested by a head of water equal to the maximum to which the tanks may be subjected but not less than 2,5 metres above the crown of the tank.

Tanks in which the oil fuel is heated are to be provided with a suitable thermometer pocket.

Water Drainage from Settling Tanks

328 Settling tanks are to be provided with means for draining water from the bottom of the tanks.

If settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains (*see* 319).

Ventilation

329 The spaces in which the oil fuel burning appliances, and the oil fuel settling and service tanks are fitted, are to be well ventilated and easy of access.

Boiler Insulation and Air Circulation in Boiler Room

330 The boilers are to be suitably lagged. The clearance spaces between the boilers and tops of the double bottom tanks and between the boilers and the sides of the storage tanks in which oil fuel or cargo oil is carried, are to be adequate for the free circulation of air necessary to keep the temperature of the stored oil well below its flash point.

331 Where water tube boilers are installed, there should be a space of at least 760 mm. between the tank top and the underside of the pans forming the bottom of the combustion spaces.

332 Smoke-box doors are to be shielded and well fitting, and the uptake joints made airtight.

Funnel Dampers

333 Dampers which are capable of completely closing the gas passages are not to be fitted to inner funnels of ships equipped for burning oil fuel only. In ships burning oil or coal alternatively, dampers may be retained if they are provided with a suitable device whereby they may be securely locked in the fully open position.

Steam Heating Arrangements

334 Where steam is used for heating oil fuel, cargo oil or lubricating oil, either in bunkers, tanks, heaters or separators, the exhaust drains are to discharge the condensate into an observation tank in a well lighted and accessible position where it can be readily seen whether or not it is free from oil (*see* E 1118).

335 The steam heating pipes in contact with oil are to be of iron, steel, approved aluminium alloy or approved copper alloy and are to be tested, after being fitted on board, to twice the maximum pressure to which they can be subjected.

336 The working pressure of steel steam heating pipes is to be determined from the formula in E 512.

Control of Pumps

337 The power supply to the oil fuel transfer and pressure pumps and to the cargo oil pumps is to be capable of being stopped from a position which will always be accessible in the event of fire taking place in the compartment in which they are situated, as well as from the compartment itself.

Precautions against Fire

338 Settling and daily service oil fuel tanks and oil fuel filters are not to be situated immediately above boilers or other highly heated surfaces.

339 Oil fuel pressure pipes are to be led, wherever practicable, remote from heated surfaces and electrical appliances, but where this is impracticable, the pipes are to have a minimum number of joints and are to be led in well lighted and readily visible positions.

340 Short sounding pipes to oil fuel tanks are not to be situated adjacent to boilers or to electric generators or motors. (For alternative sounding arrangements, *see* E 414.)

341 Water service pipes and hoses are to be fitted in order that the floor plates and tank top or shell plating in way of boilers, oil fuel apparatus or deep storage tanks in the engine and boiler spaces can at any time be flushed with sea water.

342 So far as is practicable the use of wood is to be avoided in the engine rooms, boiler rooms and tunnels of ships burning oil fuel.

343 Drip trays are to be fitted at the furnace mouths to intercept oil escaping from the burners and under all other oil fuel appliances which require to be opened up frequently for cleaning or adjustment. The arrangements are to be such that a burner cannot be withdrawn unless the oil fuel supply to that burner is shut off and that the oil cannot be turned on unless the burner has been correctly coupled to the supply line.

For alternately fired furnaces of boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

Separation of Cargo Oils from Oil Fuel

344 Pipes conveying vegetable oils or similar cargo oils are not to be led through oil fuel tanks, nor are oil fuel pipes to be led through tanks containing these cargo oils. (*See* D 2105, quoted at end of this Section.)

Oil Drainage in way of Refrigerated Cargo Chambers

345 The insulation of all oil storage tank tops is to have an air space of 50 mm. provided between the under side of the insulation and the tank top plating and the supporting battens are to be arranged to provide free drainage to the bilges. Alternatively, either 12,5 mm. thick inodorous material, or successive coatings of approved oil resisting compositions to a total thickness of about 5 mm. may be applied to the tank top plating.

346 A cofferdam is to be fitted separating deep tanks intended for the carriage of oil from refrigerated compartments unless the tank bulkhead is wholly welded including its boundary connections, in which case the cofferdam may be omitted and an air space of not less than 50 mm. arranged between the insulation and the bulkhead plating to provide for free drainage from the latter into the oil gutterway and thence to the bilges.

Provision is to be made for ventilating the cofferdam or air space, the vents being led to the open air and their outlets being fitted with a wire gauze diaphragm which can easily be removed for renewal.

Extracts from Chapter D for reference

Protection and Drainage

D 2024 Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

D 2025 Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

D 2026 Where a bulkhead, including its boundary connections, is wholly welded, the requirements of 2025 may be dispensed with, except that a gutterway is to be fitted in the boiler room.

D 2027 Ceiling on the inner bottom, if fitted, is to be laid on battens not less than 12 mm. in thickness. Battens

are to be so laid as to permit the drainage of oil to the bilges or wells.

D 2028 Drip trays or gutterways, with suitable draining arrangements, are to be provided for all tanks which do not form part of the hull structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded when the drip trays need only be fitted over the boilers.

D 2029 If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

Vegetable and Similar Oils

D 2105 Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water, by a cofferdam.

Section 4

AIR, OVERFLOW AND SOUNDING PIPES

Air and Overflow Pipes

401 Air pipes are to be fitted at the opposite end of the tank to that at which the filling pipes are placed and/or at the highest part of the tank.

Where the tank top is of unusual or irregular profile special consideration will be given to the number and position of the air pipes.

Nameplates are to be affixed to the upper ends of all air pipes.

402 Air pipes to double bottom tanks, deep tanks extending to the shell plating or tanks which can be run up from the sea are to be led to above the bulkhead deck.

Air pipes to oil fuel and cargo oil tanks, cofferdams and all tanks which can be pumped up are to be led to the open. (For height of air pipes above deck, *see* D 2409, quoted at end of this Section.)

403 The open ends of air pipes to oil fuel and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled and each opening is to be furnished with a wire gauze diaphragm of incorrodible material which can be readily removed for cleaning or renewal.

404 Air pipes from lubricating oil storage tanks may terminate in the machinery space, provided the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

405 The closing appliances fitted to tank air pipes, in accordance with D 2410, are to be of a type which will prevent excessive pressure coming on the tanks.

Provision is to be made for relieving vacuum when the tanks are being pumped out and for this purpose a hole about 9,5 mm. in diameter in the bend of the air pipe or in a suitable position in the closing device will be acceptable.

406 In the case of all tanks which can be pumped up, either by the ship's pumps or by shore pumps through a filling main, the total cross-sectional area of the air pipes to each tank or of the overflow pipes where an overflow system is provided, is to be not less than 25 per cent greater than the effective area of the respective filling pipes.

Where tanks are fitted with cross flooding connections the air pipes are to be of adequate area for these connections. Wood plugs and other devices which can be secured closed are not to be fitted at the outlets.

In wire gauze diaphragms at air pipe openings, the area of the clear opening is to be not less than the cross-sectional area required for the pipe.

Air pipes are to be not less than 50 mm. bore.

407 The arrangement of the overflow system is to be such that in the event of any one of the tanks being bilged, tanks situated in other watertight compartments of the ship cannot be flooded from the sea through the overflow main.

Air and overflow pipes are to be arranged to be self-draining under normal conditions of trim.

408 Overflow pipes are to be fitted to oil fuel storage, settling and daily service tanks when the pressure head corresponding to the height of the air pipe is greater than that for which the tanks are suitable or when the sectional area of the air pipe is less than required by 406.

The pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

A sight glass is to be provided in the overflow pipe to indicate when the tanks are overflowing or, alternatively, an alarm device is to be provided to give warning either when the tanks are overflowing or when the oil reaches a predetermined level in the tanks.

409 Where overflows from tanks which are used for the alternative carriage of oil and water ballast are connected to an overflow system, arrangements are to be made to prevent water ballast overflowing into tanks containing oil (*see* also E 324).

410 Air and overflow pipes are to be of steel or wrought iron having a minimum thickness of 5 mm. or other approved material and thickness. Steel or wrought iron pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

The portions of air and overflow pipes fitted above deck are to be of steel, wrought iron or other approved ductile material and of robust construction.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

Sounding Pipes

411 Provision is to be made for sounding all tanks, and the bilges of those compartments which are not at all times readily accessible.

The soundings are to be taken as near the suction pipes as practicable.

412 Sounding pipes, including those for the double bottom tanks below the machinery spaces, should be led to positions above the bulkhead deck which are at all times accessible.

These pipes should be as straight as practicable, and if curved to suit the structure of the ship, the curvature must be sufficiently easy to permit the ready passage of the sounding rod or chain.

Nameplates are to be affixed to the upper ends of all sounding pipes.

413 In machinery spaces and tunnels where it is not always practicable to extend the sounding pipes as mentioned in 412, short sounding pipes extending to readily accessible positions above the platform may be fitted, provided those to oil fuel and lubricating oil tanks are not situated adjacent to boilers or electric generators or motors, and are fitted with cocks having parallel plugs with permanently attached handles so loaded that, on being released, they automatically close the cocks.

Short sounding pipes to tanks other than oil tanks are to be fitted with shut-off cocks or with screw caps attached to the pipes by chains.

In passenger ships, short sounding pipes are permissible only for sounding cofferdams and double bottom tanks situated in the machinery space and are in all cases to be fitted with self-closing cocks as described in the foregoing.

414 Tank sounding devices of approved type may be used in lieu of sounding pipes. These devices are to be tested, after fitting on board, to the satisfaction of the Surveyors.

415 If gauge glasses are used for indicating the level of liquid in tanks containing lubricating oil, oil fuel or other inflammable liquid, the glasses are to be of heat-resisting quality adequately protected from mechanical damage and fitted with self-closing valves at the lower ends and at the top ends if these are connected to the tanks below the maximum liquid level.

416 Sounding pipes to oil compartments are not to terminate within refrigerated cargo chambers or in the fan and battery rooms for these chambers, nor are these pipes to terminate in enclosed spaces from which access is provided to refrigerated cargo chambers or their fan and battery rooms, if it be practicable to avoid doing so.

Where these sounding pipes do terminate in such spaces they are to be fitted with self-closing cocks having parallel plugs.

417 Sounding pipes are to be not less than 32 mm. bore. All sounding pipes, whether for compartments or tanks, which pass through refrigerated spaces, or the insulation thereof, in which the temperatures contemplated are 0° C. or below, are to be not less than 65 mm. bore.

418 All pipes, including scupper pipes, air pipes and sounding pipes which pass through chambers intended for the carriage or storage of refrigerated produce are to be well insulated.

Where such pipes pass through chambers intended for a temperature of 0° C. or below they are also to be insulated from the steel structure except in positions where the temperature of the structure is mainly controlled by the external temperature and will normally be above freezing point. Pipes passing through a deck plate within the ship side insulation, where the deck is fully insulated below and has an insulation ribband on top, are to be attached to the deck plating.

In the case of pipes adjacent to the shell plating, metallic contact between the pipes and the shell plating or frames is to be arranged as far as practicable.

The air refreshing pipes to and from refrigerated compartments need not, however, be insulated from the steel work.

419 Sounding pipes are to be of steel or wrought iron having a minimum thickness of 4,5 mm. or other approved material and thickness. Steel or wrought iron pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

420 Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes.

When slotted sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.

421 Elbow sounding pipes are not to be used for deep tanks unless the elbows and pipes are situated within closed cofferdams or within tanks containing similar liquids.

They may, however, be fitted to other tanks and may be used for sounding bilges, provided it is not practicable to lead them direct to the tanks or compartments.

The elbows are to be of heavy construction and adequately supported.

In passenger ships, elbow sounding pipes are not permissible.

Extract from Chapter D for reference

Air and Sounding Pipes

D 2409 The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather, is to be as follows :—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship, with the depth D measured to that deck ... 915 mm.

On raised quarter decks ... ... 760 mm.

On superstructure decks other than raised quarter decks, but including those extended for the full length of the ship ... ... 457 mm.

D 2410 Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

D 2411 Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

D 2412 In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

Section 5

PRESSURE PIPES

General

501 The requirements of this section are primarily intended for piping systems in which the operating pressure is 7 kg. per cm.^{2} and over.

Copper and Copper Alloy Pipes

502 Copper and copper alloy pipes are to be seamless or of approved welded type.

Branches are to be provided by cast or stamped fittings, by pipe pressings, or by other approved fabrications.

503 Brazing and welding materials are to be suitable for the operating temperature. All brazing and welding is to be carried out to the satisfaction of the Surveyors.

504 The maximum working temperatures permitted for pipe and branch materials are indicated in Table 1. Where it is proposed to use other copper alloys, particulars of chemical composition and mechanical properties at the working temperature including, if applicable, creep and rupture data, are to be submitted for consideration.

505 Where copper and copper alloy pipes are bent, they are to be made 10 per cent thicker than required by 506 to provide for thinning at the bend.

In no case is the radius of curvature at the centre line of the pipe to be less than twice the external diameter of the pipe.

506 The minimum thickness of seamless copper and copper alloy pipes is to be determined by the following formula:—

$$t = \frac{WP \times D}{2f} + C \qquad \text{or} \qquad WP = \frac{2f\,(t - C)}{D}$$

where t = thickness in millimetres,

WP = working pressure in kg. per cm.^{2}, which in the case of feed pipes, is to be 1,25 times the boiler pressure,

D = external diameter in millimetres,

f = nominal stress, in kg. per cm.^{2}, from Table 1. Intermediate values of stresses to be obtained by linear interpolation,

C = 0,8.

507 Pipes which have been hardened by cold bending are to be suitably heat treated on completion of fabrication and prior to testing by hydraulic pressure. Copper pipes are to be annealed and copper alloy pipes are to be either annealed or stress relief heat treated.

Steel Pipes

508 Steel pipes are to comply with the material requirements of P9. For alloy steels particulars of chemical composition, deoxidising medium and operating temperature are to be submitted for approval. Similar particulars are also to be submitted for carbon steel where the proposed operating temperature exceeds 399° C. The temperature limitations indicated in Table 2 are maxima for the types of steel listed but are not necessarily acceptable for all steels of these types.

509 Pipes of seamless or other approved type are to be used for feed pipes, for pressure pipes conveying heated oil and for other pressure pipes where the working pressure exceeds 17,5 kg. per cm.^{2} or the temperature exceeds 218° C.

510 Pipes other than those mentioned in 509 may be lap welded provided they are made by an approved mechanical process.

511 Pipes having forge butt welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, or for pressures exceeding 3,5 kg. per cm.^{2}.

512 The thickness of steel pipes intended for steam, feed, air, oil fuel and other pressure services is to be determined by the following formula and the thickness so obtained is suitable for straight pipes and pipes which are to be bent.

The formula does not provide for adverse corrosion conditions and steam and feed pipes over 25 mm. bore intended for use with low pressure boilers (up to 17,5 kg. per cm.^{2} working pressure) and any boilers with open feed systems are to be made one gauge (about 0,5 mm.) thicker than required by the formula.

The formula also makes provision for a manufacturing tolerance of —15 per cent and where tubes are specified to a closer negative tolerance than this figure, the rule thickness may, if desired, be reduced to suit the specified tolerance.

Seamless pipes for all pressures and temperatures:

$$t = \left(\frac{WP \times D}{2f} + 1{,}25\right) 1{,}275$$

(For lap welded pipes for pressures up to 17,5 kg. per cm.^{2} and temperatures up to 218° C. the thickness is to be 50 per cent greater than required for seamless pipes.)

Where t = thickness of pipe, in millimetres,

WP = working pressure, in kg. per cm.^{2}

For feed pipes, WP is to be taken as 1,25 times the boiler pressure, or the maximum pressure which can be developed in the feed line in normal service, whichever is the greater.

With water tube boiler installations, WP is to be taken as the approved boiler pressure for steam pipes between the boiler and integral superheater and as the pressure

TABLE 1

PIPE MATERIAL	Minimum tensile strength Kg. per mm.^{2}	0,5 per cent proof stress Kg. per mm.^{2}	NOMINAL STRESS IN KG. PER CM.^{2} AT THE FOLLOWING METAL TEMPERATURES IN °C.								
			Up to 65,5	93	121	149	177	204	232	260	288
Copper ...	22	6,3	422	408	394	337	267	211			
Aluminium Brass ...	33	12,6	703	689	668	647	422	211			
Copper Nickel 99/5 & 90/10	28,5	14,2	703	689	668	647	605	562	492	422	
Copper Nickel 70/30 ...	39,5	14,2	844	787	745	703	675	647	619	591	562

to which the superheater safety valves are set for the steam pipes leading from the superheater. Where the superheater safety valves are controlled by pilot valves operated from the saturated steam drum then WP for the steam pipes leading from the superheater is to be taken as the boiler pressure.

NOTE.—In installations where the boiler pressure, as controlled by the safety valve settings, is less than the approved boiler pressure it will be permissible for thicknesses of external steam and feed pipes to be based on the former.

D = outside diameter of pipe, in millimetres.

f = nominal stress in kg. per cm.^{2} with the following values:—

For temperatures up to and including 343° C.

f is to be taken as $\frac{1}{5}$ of the specified minimum tensile strength of the pipe material. Values of f are given in the first column of Table 2 for representative carbon steels and may be obtained on the foregoing basis for any other carbon or low alloy pipe steel approved for pressure service.

For temperatures above 343° C.

f is to be taken from Table 2 which gives values of f for a limited number of pipe steels of approved composition in common use for superheated steam pipe service. Values of f for other steels will receive special consideration.

Steam temperature is to be taken as the designed operating temperature for the pipe line provided the temperature at the superheater outlet is closely controlled. Where temperature fluctuations exceeding 14° C. above the designed temperature are to be expected in normal service the steam temperature for use with the Table is to be increased by the amount of this excess.

For intermediate temperatures, values of f may be obtained by interpolation.

Where it is proposed to use, for high temperature service, alloy steels other than those stated in the Table, particulars of tube sizes, working conditions and appropriate British or other national standard material specification giving the data required by 508 are to be submitted for consideration.

Where the material does not conform to an established standard, particulars of chemical composition, deoxidising medium, heat treatment, mechanical properties and measured or estimated long-term creep and rupture data at the proposed operating temperature are to be submitted for the purpose of assessing a safe working stress.

TABLE 2

PIPE STEEL	Minimum tensile strength kg. per mm^2.	STEAM PIPES—NOMINAL STRESS IN KG. PER CM^2 AT FOLLOWING STEAM TEMPERATURES IN °C.								
		343	371	399	427	454	482	510	538	566
Carbon	36	720	690	650	590	535	350			
	42,5	850	810	760	655	535	350			
½% Mo.	39,5	790	790	790	770	760	*			
	44	880	880	880	870	850	*			
½% Cr., ½% Mo.	39,5	790	790	790	770	760	730	530		
	44	880	880	880	870	850	770	530		
1% Cr., ½% Mo.	42,5	850	850	850	850	845	810	550	340	
2¼% Cr., 1% Mo.	42,5	850	850	850	850	845	810	590	420	325
½% Mo., ¼% V.	49	980	980	980	980	980	970	770	490	365

* ½% Mo. material is not recommended for higher temperatures than 454° C. because of its poor rupture ductility.

Pipe Joints

513 Joints in pressure pipe lines may be made by bolted flanges or by butt welds between pipes or between pipes and valve chests, or other fittings, but with the latter system it is desirable that a few flanged joints be provided at suitable positions to facilitate installation, cold "pull up" and inspection at periodical surveys.

Where pressure pipe lines are assembled and butt welded in place the piping is to be arranged well clear of adjacent structures to permit sufficient access for preheating, welding, heat treatment and examination of the joints.

In main steam pipe lines with butt welded joints, inspection bosses with screwed plugs or equivalent are to be provided in the pipe line and adjacent to the joints for the entry of introscopes or other optical devices unless other approved means for internal examination are made. If plugs are seal welded both plug and boss should be of mild steel. For the purpose of periodical surveys the locations of butt welded joints are to be clearly marked and lagging in way of these joints and inspection bosses should be portable; for hydraulic testing of the pipe lines the terminal valves should be capable of withstanding, when closed, a test pressure of twice the working pressure. In the supporting and securing arrangements for the pipe line, provision is to be made for these hydraulic test conditions.

Steel Pipe Flanges

514 Flanges are to be weldless and of material suitable for the working temperature. They may be attached to pipes by screwing and expanding or by welding. Acceptable methods of attachment are illustrated and Table 4 indicates the pressures and temperatures for which the various types are acceptable.

If backing rings are used with flange type A they are to fit closely to the bore of the pipe and should be removed after welding. The rings are to be made of the same material as the pipes or of good quality mild steel having a sulphur content not greater than 0,06 per cent. Flange types C and E are unsuitable for pipes under 76 millimetres bore.

Alternative methods of flange attachment and other types of pipe joints may be accepted provided details are submitted for special consideration.

For flange types B and C, dimension X is to be taken as t for carbon steel and $1\frac{1}{2}$t for alloy steel pipes but is to be not less than shown in Table 3.

For flange type B, dimension Y is to be taken as t for carbon steel and $1\frac{1}{2}$t for alloy steel pipes but is to be not less than 5 mm.

t is to be taken as the rule thickness of the pipe.

ACCEPTABLE METHODS OF ATTACHING FLANGES TO STEEL PIPES

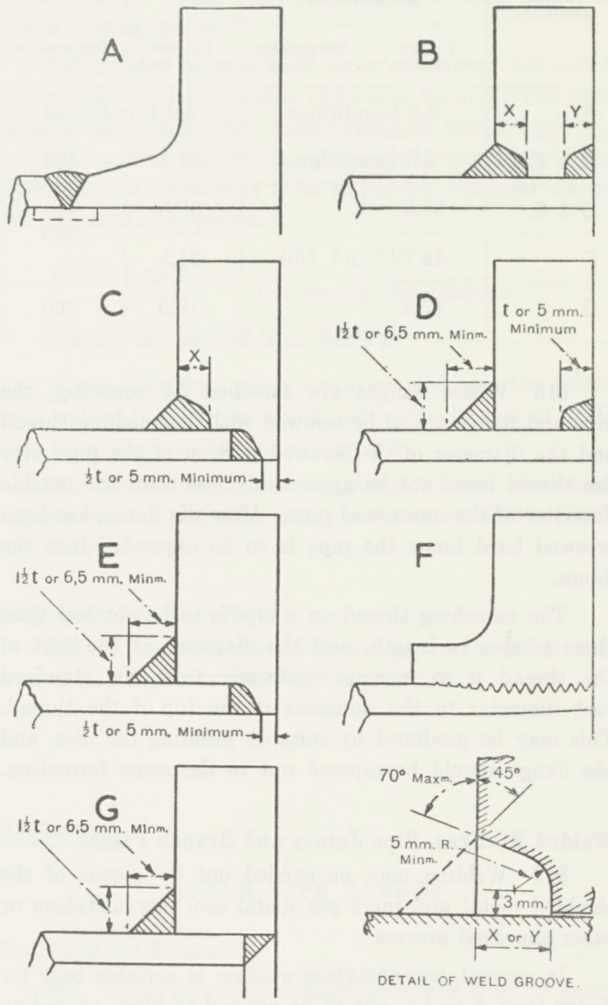


TABLE 3

Pipe Bore	Dimension X Minimum
13 mm. and 19 mm.	6,5 mm.
25 mm. to 38 mm.	8,0 mm.
50 mm. and over	9,5 mm.

TABLE 4

Type of Flange Attachment	Service and Rating			
	Feed, Air, Oil Fuel and other fluids		Steam	
	Pressure kg. per cm.²	Temperature °C.	Pressure kg. per cm.²	Temperature °C.
A	All Conditions		All Conditions	
B & C	All Conditions		52,5	454
D & E	52,5	260	38,5	399
F	42		31,5	
G	17,5		17,5	260

515 Where flanges are attached by screwing, the pipe and flange are to be screwed with a vanishing thread and the diameter of the screwed portion of the pipe over the thread must not be appreciably less than the outside diameter of the unscrewed pipe. After the flange has been screwed hard home the pipe is to be expanded into the flange.

The vanishing thread on a pipe is to be not less than three pitches in length, and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

Welded Flanges, Pipe Joints and Branch Pieces

516 Welding may be carried out by means of the shielded metal arc, inert gas metal arc, oxy-acetylene or other approved process.

In general, oxy-acetylene welding is suitable only for flange type A and is not to be applied to pipes exceeding 100 mm. diameter or 9,5 mm. thick.

When flanges are attached by welding or pipe-to-pipe joints are butt welded using the oxy-acetylene or metal arc process the filler rods, electrodes and fusible root inserts used are to be suitable for the materials of the parts to be joined.

All welding work is to be carried out in shop or ship in positions free from draughts or rapid changes of temperature.

Preheating under temperature control is to be employed when necessitated by the dimensions and composition of the materials to be welded and is to be effected by a method which ensures uniformity of temperature at the joint. The method of heating and the means adopted for temperature control are to be to the satisfaction of the Surveyors.

Where butt welds are employed in the attachment of flange type A, in pipe-to-pipe joints or in the construction of branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding, or machining provided the pipe wall is not reduced below the designed thickness. If the parts to be joined differ in wall thickness, the thicker wall is to be gradually tapered to that of the thinner at the butt joint. The welding necks of valve chests are to be sufficiently long to ensure that the valves are not distorted as the result of welding and subsequent heat treatment of the joints.

Butt welds may be reinforced externally by additional runs of weld metal. All welds in high pressure and high temperature pipe lines are to have a smooth surface and even contour; if necessary they are to be made smooth by grinding. No undercutting of the pipe at the edges of the weld is acceptable.

517 Branches may be attached to pressure pipes by means of welding provided the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively the thicknesses of pipe and branch are to be increased to maintain the strength of the pipe.

These requirements also apply to fabricated branch pieces.

518 The welding procedure proposed for the attachment of flanges, valve chests and other fittings to pipes, pipes-to-pipes and the fabrication of branch pieces, whether in carbon or alloy steel, is to be approved by the Surveyors in the first instance before work is commenced. For this purpose representative specimens of such parts will be required for examination and test.

The assembly for the weld procedure test and the welding technique should simulate the conditions under which the work is to be done on the installation. Test welds are to be examined for defects by the appropriate method specified in 519. The test welds are then to be sectioned at positions selected by the Surveyor, one surface of each section being prepared, etched and examined for defects in the weld and heat affected zones. In the case of pipes or branch pieces of alloy steel, mechanical tests and tests to destruction may also be required to demonstrate that the joints are of adequate strength. Check tests of the quality of the work of the welders are to be carried out periodically at the Surveyor's discretion.

519 All welds attaching flanges and branches to alloy steel pipes of 76 mm. bore and over are to be examined to ensure as far as possible that the welds are satisfactory. These examinations are to be carried out by radiography where practicable or by other approved methods.

Butt joints in all welded steam pipe lines of carbon or low alloy steel and of 76 mm. bore and over are to be examined by radiographic or other approved methods. The techniques are to be applied to the satisfaction of the Surveyor and are to be of a sensitivity which is suitable to disclose detrimental defects. For radiographic examinations and required standards of sensitivity *see* J 1923.

Fillet welds in fabricated branch pieces are to be examined by magnetic crack detection methods.

Small detrimental defects, if found, are to be cut out and the seam re-welded and re-examined. In the case of major defects the joint is to be re-machined and completely re-welded.

Heat Treatment of Steel Pipes and Branch Pieces

520 Carbon steel pipes intended either for pressures above 10,5 kg. per cm.^{2} or temperatures above 260° C. are to be stress relieved where they have been heated for bending the pipe or for any other purpose and where the flanges have been attached by metal arc welding. Where oxy-acetylene welding has been employed, the pipes are to be normalised.

All alloy steel pipes and fabricated branch pieces are to be carefully and suitably heat treated under accurate temperature control after cold or hot bending, welding or other hot work. Stress relieving or normalising may be used after metal arc welding, and normalising is required after bending and oxy-acetylene welding. Other methods of heat treatment will be considered on submission of full details.

Suitable temperatures for heat treatment are given in Table 5 and should be maintained for one hour per 25 mm. of wall thickness.

TABLE 5

Pipe steel	Temperature limits for	
	Stress Relieving	Normalising
Carbon	1110–1200°F. 600– 650°C.	1700–1760°F. 927– 960°C.
½% Mo. ½% Cr., ½% Mo. 1% Cr., ½% Mo.	1150–1225°F. 620– 663°C.	1700–1760°F. 927– 960°C.
2¼% Cr., 1% Mo.	1200–1255°F. 650– 680°C.	1740–1780°F. 950– 970°C.
½% Mo., ¼% V.	1185–1240°F. 640– 670°C.	1740–1780°F. 950– 970°C.

Hydraulic Test Pressures

521 All main steam and feed pipes are, on completion, to be tested by hydraulic pressure to not less than twice the working pressure as defined in 506 and 512. Other pipes are to be similarly tested when intended for working pressures above 10,5 kg. per cm.^{2}

In the case of superheat steam pipes and fabricated branch pieces a test pressure (TP) is to be applied so that these parts are subjected, under hydraulic test, to approximately the same wall stress as saturated steam pipes. The hydraulic test pressure is to be as follows, but need not be more than 316 kg. per cm.^{2}

$$TP = 2\ WP \times \frac{f \text{ at } 343^\circ \text{ C.}}{f \text{ at working temperature}}$$

Where f is obtained from Table 2.

If the individual pipes are assembled and the joints butt welded in place, an additional hydraulic test of 2WP is to be applied to the erected pipe line.

For the testing of the completed oil fuel pipes and heating coil systems after fitting on board *see* E 310, E 312 and E 335.

Cast Iron Heating Pipes

522 Where it is desired to use pressure pipes of cast iron, details are to be submitted.

Section 6

STEAM PIPE RANGES

Provision for Expansion

601 In all steam pipe ranges provision is to be made for expansion and contraction to take place without unduly straining the pipes.

Where corrugated pipes are used, particulars are to be submitted.

Drainage

602 The slope of the pipes and the number and position of the drain cocks or valves are to be such that water can be efficiently drained from any portion of the steam pipe range when the ship is in normal trim and is either upright or has a list up to 5 degrees.

Arrangements are to be made for ready access to the drain cocks or valves.

Pipes in way of Holds

603 In general, steam pipes are not to be led through spaces which may be used for cargo, but where it is impracticable to avoid this arrangement, plans are to be submitted for consideration. The pipes are to be efficiently secured and insulated and well protected from mechanical damage. Pipe joints are to be as few as practicable and preferably butt welded. After fitting in place, the pipes are to be tested by hydraulic pressure to twice the working pressure.

If these pipes are led through shaft tunnels, pipe tunnels in way of cargo holds or through duct keels, they are to be efficiently secured and insulated.

Reduced Pressure Lines

604 Pipe lines which are situated on the low pressure side of reducing valves and which are not designed to withstand the full pressure at the source of supply are to be fitted with pressure gauges and with relief valves having sufficient discharge capacity to protect the piping against excessive pressure.

Valves and Fittings

605 Valves and fittings intended either for steam pressures above 10,5 kg. per cm.^{2} or temperatures above 218° C. are to be of steel, carbon or low alloy, or other approved material suitable for the working temperature.

Castings of bronze, iron and carbon steel may be used within the following limits of temperature and pressure:—

Bronze	218° C. 10,5 kg. per cm.^{2}
Iron	232° C. 10,5 kg. per cm.^{2}
Carbon Steel	454° C. all pressures.

Hydraulic Test Pressure

606 All main steam and feed valves and fittings are to be tested by hydraulic pressure to not less than twice the working pressure as defined in E 506 and E 512. Other valves and fittings are to be similarly tested when intended for working pressures above 10,5 kg. per cm^2.

For the testing of boiler mountings *see* J 302 and J 1510.

Steam for Fire Extinguishing in Cargo Holds

607 Where steam is used for fire extinguishing in cargo holds, provision is to be made to prevent damage to cargo by leakage of steam or by drip.

Details of the proposed precautionary measures are to be submitted.

Section 7

BOILER FEED WATER SYSTEMS

Feed Pumps

701 Two separate means of feed are to be provided for all main and auxiliary boilers which are required for essential services, with the exception of boilers in which steam is generated exclusively by exhaust gases or steam, where one means of feed will be accepted provided an alternative steam supply is available.

702 Two or more feed pumps are to be provided of sufficient capacity to supply the boilers under full load conditions with any one pump out of action.

703 Feed pumps may be worked from the main engines or may be independently driven but at least one of the pumps required in 702 is to be independently driven.

704 In twin screw ships in which there is only one independent feed pump each main engine is to be fitted with a feed pump. Where all the feed pumps are independently driven, the pumps are to be connected to deal with the condensate from both engines or from either engine.

705 Independent feed pumps required for feeding the main boilers are to be fitted with automatic regulators for controlling their output.

706 Where main-engine driven feed pumps are fitted and there is only one independent feed pump, a harbour feed pump or an injector is to be fitted to provide the second means of feed to the boilers which are in use when the main engines are not working.

707 Feed pumps are to be provided with valves or cocks interposed between the pumps and the suction and the discharge pipes so that any pump may be opened up for overhaul while the others continue in operation.

Sea Suction

708 One of the independent feed pumps is to be provided with an emergency suction to the sea, except in the cases mentioned in 709.

Suctions are also to be provided from this pump to the hotwell or condenser, unless suitable stand-by connections have already been provided for this purpose.

709 The sea suction to a feed pump may be omitted if large reserve feed tanks are provided and an evaporator of adequate capacity is fitted.

Reserve Feed Water

710 All ships fitted with boilers are to be provided with storage space for reserve feed water, the structural and piping arrangements being such that this water cannot be contaminated by oil or oily water.

General Service Pump

711 An auxiliary independent feed pump may be used for general service, provided it is not connected to tanks containing oil fuel or cargo oil or to tanks, cofferdams and bilges containing oily water.

The valves on the suction pipes from the hotwell or condenser and the feed drain tank or filter are to be of non-return type.

Filters

712 Where superheated steam is used in main or auxiliary engines of reciprocating type, filters are to be fitted to provide for the continuous filtration of the boiler feed water.

713 Where a direct contact heater is supplied with exhaust steam from engines of reciprocating type, the feed water from the heater is to be led through the filters required by 712 or through additional filters arranged to provide for continuous filtration.

Cross-references

714 For materials, working pressure and test pressure of feed pipes, *see* E 501 to E 521.

For feed water level regulators for water tube boilers, *see* J 1708.

Section 8

ENGINE COOLING WATER SYSTEMS

Main Supply

801 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to the lubricating oil and fresh water coolers and air coolers for electric propelling machinery where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

Alternative Supply

802 Provision is also to be made for a separate emergency supply of cooling water from a suitable pump.

When selecting a pump for this purpose, consideration is to be given to the maximum pressure which it can develop if the overboard discharge valve is partly or fully closed and, when necessary, condenser doors, water boxes, etc., are to be protected by an approved device against inadvertent over-pressure. *See* H 445 for the hydraulic test pressure which condensers are required to withstand.

Sea Inlets

803 Not less than two sea inlets are to be provided for the pumps supplying the salt water cooling system, one for the main pump and one for the stand-by pump. Alternatively, the sea inlets may be connected to a suction line available to main and stand-by pumps.

These inlets are to be low inlets and one of them may be the ballast pump or general service pump sea inlet.

Stand-by Fresh Water Pump

804 Where fresh water cooling is employed, a stand-by fresh water pump need not be fitted if there be suitable emergency connections from a salt water system.

Cooling Water Supply to Auxiliaries

805 Where each auxiliary is fitted with a cooling water pump, stand-by means of cooling need not be provided. Where, however, a group of auxiliaries is supplied with cooling water from a common system, a stand-by cooling water pump is to be provided for this system. This pump may be a suitable general service pump.

The auxiliary cooling water pumps are to be connected to not less than two sea inlets, preferably one on each side of the ship.

Strainers

806 Where sea water is used for the direct cooling of the main engines and essential auxiliary engines, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply.

Relief Valves

807 Cooling water pumps worked from the main engines are to be provided with relief valves on the pump discharge.

Copper and Copper Alloy Piping Systems

808 When non-ferrous pipes are proposed for fresh and sea water piping systems, details of the materials and the duty for which they are intended may be submitted to the Society for approval.

In the selection of components for sea water piping systems, care should be taken to avoid metal combinations which may lead to galvanic corrosion in service.

See Chapter R(D) for Guidance Notes on Metal Pipes for Water Services.

Section 9

LUBRICATING OIL SYSTEMS

Pumps

901 In ships of unrestricted class in which the lubricating oil for the main engines (steam engines, oil engines, turbines or electric propelling motors), is circulated under pressure, a stand-by lubricating oil pump is to be provided where the following conditions apply:—

(a) The lubricating oil pump is independently driven and the total output of the main engines exceeds 500 b.h.p.

(b) One main engine with a built-in lubricating oil pump is fitted and the output of the engine exceeds 500 b.h.p.

(c) Two or more main engines each with a built-in lubricating oil pump are fitted and the output of each engine exceeds 500 b.h.p.

The stand-by pump is to be of sufficient capacity to maintain the supply of oil for normal conditions with any one pump out of action. The pump is to be fitted and connected ready for immediate use but where this is not convenient in the case of high speed oil engines with built-in pumps, a complete spare pump may be accepted for installation of type (c).

Similar provision is to be made where separate lubricating oil systems are employed for piston cooling, the operation of reverse reduction gears, oil operated couplings and controllable pitch propellers, unless approved alternative arrangements are provided.

902 Independently driven pumps of rotary type are to be fitted with a non-return valve on the discharge side of the pump.

Alarms

903 All main and auxiliary engines and turbines are to be provided with alarm devices to give warning of the failure of, or an appreciable reduction in, the pressure of the oil supply. Where a discharge filter is fitted the alarm device is to be situated on the outlet side of the filter.

Emergency Supply for Propulsion Turbines and Propulsion Turbo-Generators

904 A suitable emergency supply of lubricating oil is to be arranged to come automatically into use in the event of a failure of the supply from the pump.

The emergency supply may be obtained from a gravity tank containing sufficient oil to maintain adequate lubrication for not less than 6 minutes, and in the case of propulsion turbo-generators until the unloaded turbine comes to rest from its maximum rated running speed.

Alternatively, the supply may be provided by the stand-by pump or by an emergency pump. These pumps are to be so arranged that their availability is not affected by a failure in the power supply.

Filters

905 Where the lubricating oil for main propelling engines is circulated under pressure, provision is to be made for the efficient filtration of the oil. The filters are to be capable of being cleaned without stopping the engine or reducing the supply of filtered oil to the engine.

906 Where filters are fitted on the discharge side of the lubricating oil pump, a relief valve in close circuit is to be fitted between the pump and the filter if the pump is capable of developing a pressure exceeding the design pressure of the system.

907 In the case of propulsion turbines and their gears, arrangements are to be made for the lubricating oil to pass through magnetic strainers and fine filters.

NOTE:—It is recommended that the openings in the filter elements be not coarser than 50 microns, especially for the supply to turbine thrust bearings.

Pipes and Fittings

908 Extreme care is to be taken to ensure that lubricating oil pipes and fittings, before installation, are free from scale, sand, metal particles and other foreign matter.

Drip Trays

909 In ships built of wood, easily drained metal or metal-lined trays are to be fitted to prevent saturation of the woodwork by leakage from the engine and its filters.

Lubrication of Bearings

910 The arrangements for lubricating bearings and for draining crankcase and other oil sumps of main and auxiliary engines, gear cases, electric generators, motors

and other running machinery are to be so designed that lubrication will remain efficient with the ship inclined from the normal at any angle up to 15 degrees transversely and when pitching 10 degrees longitudinally and when rolling up to 22½ degrees from the vertical.

911 For details of the requirements relating to the lubrication of bearings of electric generators and motors, *see* M 107.

Valves and Cocks

912 Outlet valves and cocks on lubricating oil service tanks, other than double bottom tanks, situated in machinery spaces are to be capable of being closed locally and from positions outside the compartment which will always be accessible in the event of fire occurring in these spaces. Remote controls need only be fitted to outlet valves and cocks which are open in normal service and are not required for other outlets such as those on storage tanks. Indicators are to be provided at the valves and cocks and at the remote control positions to show whether they are open or closed.

In the case of very small tanks consideration will be given to the omission of remote controls.

Cross-References

913 For air and sounding pipes and gauge glasses, *see* E 404, E 413 and E 415.

Section 10

PUMPING ARRANGEMENTS FOR SHIPS NOT FITTED WITH PROPELLING MACHINERY

Hand Pumps

1001 Where auxiliary power is not provided, hand pumps are to be fitted in number and position as may be required for the efficient drainage of the ship.

The pumps are to be capable of being worked from the upper deck or from positions above the load water line which are at all times readily accessible.

The suction lift is not to exceed 7,3 metres, and is to be well within the capacity of the pump.

1002 The sizes of the hand pumps are not to be less than given in the following table:

Tonnage under Upper Deck	Hand Pumps	
	Diameter of barrel of bucket pump Millimetres	Bore of suction pipe of bucket pumps and semi-rotary pumps Millimetres
Not exceeding 500 tons ...	100	50
Above 500 tons but not exceeding 1,000 tons ...	115	57
Above 1,000 tons but not exceeding 2,000 tons ...	125	65
Above 2,000 tons	140	70

Where the ship is closely subdivided into small watertight compartments 50 mm. bore suctions will be accepted.

Power Pumps

1003 In ships in which auxiliary power is available on board, power pump suctions are to be provided for dealing with the drainage of tanks and of the bilges of the principal compartments.

The pumping arrangements are to be as required for self-propelled ships in so far as these requirements are applicable, duly modified to suit the size and service of the ship.

Details of the pumping arrangements are to be submitted for special consideration.

Section 11

PETROLEUM AND OTHER LIQUID CARGOES HAVING A FLASH POINT BELOW 65,5° C.

General

1101 The following requirements are based on the assumption that the ships are of normal tanker type having the main propelling machinery aft.

Departures from normal type will require special consideration.

Cargo Oil System

1102 A complete system of piping and pumps is to be fitted for dealing with the cargo oil.

1103 Cargo pump rooms are to be enclosed by oiltight bulkheads and are to have no direct communication with machinery spaces.

1104 Pumps for the purpose of filling or emptying the cargo oil tanks are to be used exclusively for this purpose, except as provided in 1107. They are not to have any connections to compartments outside the range of cargo oil tanks.

Means are to be provided for stopping the cargo oil pumps from a position outside the pump rooms, as well as at the pumps.

1105 The pumps are to be provided with effective escape valves which are to be in close circuit, i.e., discharging to the suction side of the pumps.

1106 Expansion joints or bends are to be provided where necessary in the cargo pipe lines.

Terminal pipes, valves and other fittings in the cargo loading and discharging lines to which shore installation hoses are directly connected are to be of steel or other approved ductile material. They are to be of robust construction and strongly supported.

1107 Provision is to be made for the bilge drainage of the cargo pump rooms by pump or bilge ejector suctions. The cargo pumps or cargo stripping pumps may be used for this purpose, provided the bilge suctions are fitted with screw-down non-return valves and, in addition, an isolating valve or cock be fitted on the pump connection to the bilge chest. The pump room bilges of small tankers may be drained by means of a hand pump having a 50 mm. bore suction.

Pump room suctions are not to enter machinery spaces.

1108 Pump rooms are to be provided with ready means of access and adequate ventilation.

1109 Ullage plugs or sighting ports are to be provided at each tank to enable the amount of ullage to be ascertained.

Ullage plugs or sighting ports should not be fitted in any enclosed space.

1110 Provision is to be made for the gas freeing of the cargo oil tanks when the cargo has been discharged and for the ventilation and gas freeing of all compartments adjacent to cargo oil tanks.

1111 Vapour pipes are to be fitted to cargo oil tanks and connected through shut-off cocks or valves or pressure-vacuum valves to a vapour line led up the mast or other post to a safe height above the weather deck. The outlets from these vapour mains are to be provided with readily renewable wire gauze or safety heads of approved types. If alternative means of dealing with the vapour are desired, details are to be submitted.

Bilge, Ballast, Oil Fuel and other Piping not within the Cargo Oil System

1112 The pumping arrangements in the machinery space and at the forward end of the ship are to comply with the requirements for general cargo ships in so far as they are applicable and with the special requirements detailed in 1113 to 1117.

1113 A separate power pump is to be fitted in a suitable compartment forward of the cargo tanks to deal with bilge drainage, water ballast and oil fuel pumping at the fore end of the ship.

In small tankers, a forward power pump may be dispensed with, provided suitable alternative arrangements are made, details of which are to be submitted.

1114 Where deep cofferdams can be filled with water ballast, a ballast pump in the main engine room may be used for emptying the after cofferdam, provided the suction be led direct to the pump and not to an engine room pipe system. The ballast pump in the forward pump room may be used for emptying the forward cofferdam.

1115 Cofferdams are not to have any direct connections to the cargo oil tanks or cargo oil lines.

Where intended to be dry compartments, after cofferdams adjacent to the pump room may be drained by a cargo pump, provided isolating arrangements are fitted in the bilge system as required by 1107; forward cofferdams may be drained by the bilge and ballast pump in the forward pump room. Alternatively, cofferdams may be drained by hand pumps or bilge ejectors.

Cofferdams are to be provided with sounding pipes and with air pipes led to the open. These air pipes are to be fitted with wire gauze diaphragms at their outlets.

1116 Bilge, ballast, oil fuel and other piping connected to the pumps at the ends of the ship are not to pass through the cargo oil tanks or have any connection with these tanks.

Cargo oil pipes are not to pass through ballast or oil fuel tanks or through compartments which are external to the cargo oil system.

1117 The oil fuel bunkering system is to be entirely separate from the cargo oil system.

Steam and Exhaust Piping

1118 Where heating coils are provided in the cargo oil tanks they are to be made and fitted under the usual conditions of survey and testing. (*See* E 334 to E 336, E 522 and E 601 to E 607.)

An observation tank is to be provided for the heating coil drains and is to be situated in a well ventilated and well lighted part of the machinery space remote from the boilers.

Spectacle flanges are to be provided in the main steam and exhaust pipes to the cargo oil heating system, at a suitable position forward of the machinery space bulkhead, so that the lines can be blanked off in circumstances where cargo oil does not require to be heated or where heating coils are not fitted in the tanks.

1119 Steaming out and fire extinguishing connections for cargo oil tanks or cargo oil pipe lines are to be fitted with valves of non-return type and the main supply to these connections is to be fitted with a master valve placed in a readily accessible position clear of the tanks.

1120 In the cargo pump rooms, drain pipes from steam or exhaust pipes or from the steam cylinders of the pumps are to terminate well above the level of the bilges.

Motive Power of Cargo Oil Pumps

1121 Where the cargo oil pumps are not driven by steam, plans of the arrangements for driving the pumps are to be submitted.

1122 Where cargo pumps are driven by shafting which passes through a pump room bulkhead or deck, gastight glands with efficient means of lubrication are to be fitted to the shaft at the pump room plating.

Auxiliary Machinery outside Main Engine Room

1123 Internal combustion engines are not to be situated within pump rooms, cofferdams or other spaces liable to contain petroleum or other explosive vapours.

(For requirements for electrical equipment within such spaces, *see* M 16.)

Section 12

LIQUEFIED GASES

General

1201 The following requirements are intended primarily for liquefied Methane, Propane, Butane and other petroleum gases but may be applied to other liquefied gases with comparable properties and carrying hazards subject to special consideration in each case.

PART 1

LIQUEFIED PETROLEUM GASES CARRIED IN INDEPENDENT SPHERICAL OR CYLINDRICAL TYPE TANKS AT PRESSURES ABOVE 0,7 kg. per cm.^{2} AND AT AMBIENT OR LOWER TEMPERATURES

Plans

1202 Plans showing filling, discharging, venting and inerting pipe arrangements, together with particulars of the intended cargo, maximum vapour pressure and minimum liquid temperature are to be submitted.

Hold Drainage

1203 Provision is to be made for the drainage of holds in which the cargo tanks are situated. Normal drainage is to be effected by hand pumps, bilge ejectors or other approved means. Hand pumps are to be made of gunmetal or other non-ferrous material and are to be fitted on deck having discharges directly overboard. Bilge ejectors are to be fitted in the holds and may be operated by steam or water.

1204 In addition to the above requirements, bilge suctions as required by E 2 are to be provided for use in an emergency. These suctions are to be led direct to the bilge pump suction chest and are to be blanked off in normal service by spectacle blank flanges in readily accessible positions in the machinery space. Screw-lift valves are to be fitted between the spectacle flanges and the bulkhead so that the pipes can be isolated if it is necessary to change over the spectacle flanges. Notice plates are to be fitted in the vicinity of the valves stating that the bilge suctions are not to be used except in case of grave emergency

A brass rod is to be provided for sounding the holds.

Connections to Cargo Tanks

1205 Cargo tanks are to be provided with the necessary connections for liquid and gas lines, relief valves, liquid level gauging devices, pressure gauges and thermometers.

1206 All connections are to be situated above the weather deck and protected from damage.

Shut-off Valves

1207 Connections for filling and emptying the cargo tanks of liquid or gas are to be fitted with double shut-off valves: one is to be a manually operated shut-off valve and the other one of the following:—

(*a*) a remote controlled valve which is capable of being closed from the loading station and at least two other widely separated positions on the upper deck, or

(*b*) an excess flow valve which will close automatically and prevent the tank emptying in the event of a pipe breaking.

In the case of single purpose connections which are required only for the inlet of liquid or gas a non-return valve would be accepted in place of (*a*) or (*b*) above.

Shut-off valves are to be fitted with legible nameplates in prominent positions.

Pressure Relief Valves

1208 Each cargo tank is to be protected by one or more pressure relief valves of approved design and capacity discharging into a vapour relief main led up the mast or other post to a safe height above the weather deck and well removed from possible sources of ignition.

The relief valves should be of sufficient capacity to discharge the vapours formed by exposure of the cargo tank walls to fire. Calculations on which the area of the valves are based are to be submitted.

In every case the combined discharge capacity of the pressure relief valves is to be sufficient to prevent a rise of pressure in the tank to more than 10 per cent above the design vapour pressure.

The discharge capacity of a pressure relief valve is to be established by type tests carried out in the presence of the Surveyors or by an independent authority recognised by the Society.

Pressure relief valve connections are to be attached to the tanks near the highest part of the vapour space.

Shut-off valves are not to be fitted between the tanks and the pressure relief valves unless there are two or more relief valves per tank and the shut-off arrangements are so devised that pressure relief valves having the required discharge capacity are always in communication with the tank.

Shut-off valves are not to be fitted between the pressure relief valves and the vapour relief main outlet.

Each pressure relief valve is to be tested in the presence of the Surveyors to demonstrate that it commences to discharge at a pressure not more than 3 per cent above the maximum vapour pressure for which the tanks have been approved.

Vacuum Relief Valves

1209 Consideration should be given to the ability of the cargo tanks to withstand any vacuum which may arise in service or when the tanks are being gas freed. Where necessary, vacuum relief valves are to be fitted and vacuum relief obtained from a supply of cargo gas or an inert gas system.

Vapour Relief Systems

1210 The vapour relief main is to have a cross-sectional area equal to the combined area of the branch vapour relief pipes, but if there are three or more cargo tanks the following percentage reductions in the area of the vapour relief main will be allowed:—

3 cargo tanks		10%	reduction
4	,,	,, 20%	,,
5	,,	,, 30%	,,
6	,,	,, 40%	,,
or more			

The vapour relief system outlet is to be arranged to discharge the gases in a direction above the horizontal and the outlet is to be fitted with a flameproof wire gauze diaphragm and protected from the weather. Suitable drainage arrangements for condensate water are to be provided for the vapour relief lines.

Level Gauges

1211 Liquid level gauging devices are to be of approved type and are to indicate the maximum level to which the tank may be filled having regard to the nature of the cargo and its temperature.

Pressure Gauges

1212 Pressure gauges are to be marked with the working pressure of the tank. Pressure gauge connections are to be fitted with a manually operated shut-off valve.

Cargo Piping System

1213 A complete system of piping, pumps, compressors, etc., is to be provided for dealing with the cargo. The system is to be used exclusively for this purpose and is not to have connections to compartments outside the range of the cargo tanks.

All piping in the cargo handling system is to be situated above the weather deck.

1214 All materials used in the piping systems must be suitable for the proposed service. Where the operating metal temperature is below 0° C., specifications of the materials for pipes and fittings giving chemical composition and mechanical properties at the service temperature are to be submitted for approval.

1215 All piping, valves and fittings are to be suitable for the maximum pressure to which the system may be subjected, but not, in any case, less than a pressure of 10,5 kg. per cm.^{2}.

Piping subject to pressure is to be of seamless or other approved type and is to comply with the requirements of E 5.

Valves and fittings are to be of steel or other approved ductile material.

1216 Joints may be of butt-welded or flanged type. Couplings of approved type may be used for joints 38 mm. diameter or smaller. Low grade screwed joints are not acceptable.

1217 Provision is to be made in the pipe lines for the effects of expansion and contraction. If expansion pieces are used they are to be of the bellows type. All piping is to be suitably supported and secured.

1218 Low temperature pipes are to be protected against external corrosion, adequately insulated and provided with temperature isolation from the hull. Drip trays are to be fitted where cargo leakage or spillage is likely to occur.

1219 Sections of piping which may contain liquid gas and which can be isolated are to be provided with relief valves discharging to the vapour relief main or other safe position.

1220 Connections are to be provided so that the cargo tanks and the cargo handling system can be purged with an inert gas. Provision is also to be made for the gas-freeing of the cargo tanks.

1221 Terminal pipes, valves and fittings in the cargo handling system, to which shore installation hoses are directly connected, are to be of robust construction and strongly supported.

Suitable arrangements are to be provided for relieving the liquid and gas lines of internal pressure before the shore installation hoses are disconnected.

Earthing of Tanks and Pipes

1222 Where tanks and pipes are separated from the hull structure by insulating materials they are to be effectively earthed to the hull by at least two earthing connections as a precaution against the effects of static charges.

Cargo Pumps and Gas Compressors

1223 Pumps and compressors may be installed on the open deck provided they are suitably located and protected from mechanical damage. Alternatively, the pumps and compressors may be fitted in a well-ventilated compartment outside the machinery space. This compartment is to be treated as a dangerous space to which the requirements of M 16 for electrical equipment are applicable.

1224 Where pumps and compressors are driven by shafting which passes through a bulkhead, gastight glands with efficient means of lubrication are to be fitted to the shafts in way of the bulkhead.

1225 The pumps are to be fitted with relief valves if they are capable of developing a discharge pressure greater than the design pressure of the piping system. The relief valves are to discharge to the suction side of the pumps.

1226 Compressors are to be fitted with relief valves discharging to the vapour relief main, or other safe position. The relief valves are to be so proportioned and adjusted that the accumulation with the outlet valves closed will not exceed 10 per cent of the maximum working pressure.

1227 The pumps and compressors are to be capable of being stopped from the loading station and from a position outside the range of the cargo tanks.

Refrigeration Equipment and Piping

1228 Where the cargo is refrigerated or the boil-off is re-liquefied, the arrangements will be specially considered. In ships classed for unrestricted service the capacity of the refrigerating machines is to be based on a sea temperature of 30° C. and on an ambient air temperature of 45° C. Two or more refrigerating units are to be provided of capacity sufficient to maintain the liquid cargo at the carrying temperature with any one unit out of use.

PART 2

LIQUEFIED METHANE AND PETROLEUM GASES CARRIED IN INDEPENDENT RECTANGULAR TYPE TANKS AT PRESSURES OF 0,7 kg. per cm.^{2} OR LESS AND AT TEMPERATURES BELOW AMBIENT

The following paragraphs of Part 1 are applicable:—

Plans	1202
Connections to Cargo Tanks ...	1205 and 1206
Pressure Relief Valves	1208
Vacuum Relief Valves	1209
Vapour Relief System	1210
Cargo Piping System	1214 to 1221 inclusive
Earthing of Tanks and Pipes ...	1222
Refrigeration Equipment and Piping	1228

Shut-off Valves

1229 Each cargo tank is to be provided with separate connections for cooling down, filling and discharge purposes. These connections are to have shut-off valves or cocks manually controlled and fitted with legible nameplates in a prominent position.

Filling connections are to be provided with internal pipes led to the bottom of the tanks.

Level Gauges

1230 An approved liquid level gauging device of the closed type is to be provided for each tank. This gauge should be arranged to give audible and visible warning of the high and low liquid levels in the tank.

An independent high level alarm device is also to be provided for each tank which, besides giving audible and visible warning of over-filling, is capable of closing the terminal valve at the cargo loading station.

Liquid level gauging and alarm devices are to be adequately protected against damage.

Pressure Gauges

1231 Means are to be provided for indicating the pressure in each cargo tank and containment space.

Thermometers

1232 Thermometers are to be of the remote reading type and are to be marked with the mimimum permitted carrying temperature for the tank.

Instrument and Control Rooms

1233 Gas detection, pressure recording, safety and alarm devices, etc., are to be installed in a well ventilated room in an approved position.

Where gas detecting devices are fitted in a room containing electrical equipment which is not intrinsically safe, the arrangements are to be such that there is no possibility of gas leakage reaching the electrical equipment. Details are to be submitted.

Cargo Pumping System

1234 A complete pumping system is to be provided for dealing with the cargo. The system is to be used exclusively for this purpose and is not to have connections to compartments outside the range of the cargo tanks.

Terminal valves at the loading station are to be capable of being closed locally and from at least two other widely-separated positions on the upper deck.

All piping in the cargo pumping system is to be situated above the weather deck.

Emergency Discharge of Cargo

1235 Where cargo tanks are surrounded by void spaces, provision is to be made for draining such spaces in the event of tank leakage or rupture.

Arrangements are to be made so that the liquid cargo can be discharged overboard in an emergency. The discharge nozzle should preferably be at the stern of the ship and so designed that the liquid discharge will reach the water as far from the ship as possible.

Cargo Pumps

1236 All cargo pumps are to be capable of being stopped from the loading station and from a position outside the range of the cargo tanks. The pumps are to be fitted with relief valves if they are capable of developing a discharge pressure greater than the design pressure of the piping system. The relief valves are to discharge to the suction side of the pump.

Stand-by means for pumping out each cargo tank are to be provided.

1237 In the case of deep well pumps driven from positions above the cargo tanks, gastight glands with efficient means of lubrication are to be provided where the driving shafts enter the tanks.

1238 If the cargo pumps are driven by submerged electric motors, the arrangements will be subject to special consideration and must ensure that under all conditions air will not be admitted to the cargo tanks.

Cross-reference

1239 Cargo tanks are to be constructed as required by J 25 or D 71 whichever is applicable.

Ventilation arrangements are to comply with ... D 72

Electrical arrangements are to comply with ... M 16

The use of Methane as fuel for propulsion purposes ... ... *see* R (A)

9th December, 1965

Chapter F

FIRE PROTECTION, DETECTION AND EXTINCTION

PART 1

FIRE DETECTION AND EXTINCTION IN PASSENGER, CARGO AND OTHER SHIPS

Section 1

GENERAL

101 The requirements of Part 1 of this Chapter apply to passenger and cargo ships to be classed for unrestricted service.

102 While the requirements satisfy the regulations of the International Convention for the Safety of Life at Sea, 1960, attention should also be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered. Compliance with these statutory requirements may be accepted as meeting the requirements of this Chapter.

103 Consideration will be given to special cases where the arrangements are equivalent to those required by these Rules. Consideration will also be given to fire extinguishing equipment and arrangements for small ships and ships to be classed for restricted or special service.

104 Fire fighting appliances—hoses, extinguishers, gas cylinders, emergency pumps, breathing apparatus, fireman's axe, etc.—which have been approved by a National Authority as complying with the regulations of the International Convention for Safety of Life at Sea, 1960, may be accepted as meeting the requirements of this Chapter.

105 Where it is proposed to apply centralised, bridge, or automatic controls to propulsion machinery and essential auxiliaries and it is intended that the engine and/or boiler rooms will not be continuously manned at sea, an approved fire detection system, in accordance with F 326 to F 328, is to be provided in these spaces (*see* G 111).

NOTE.—Having regard to the greater fire risk when a ship is in port, and the possibly reduced level of manning, it is recommended that an approved fire detection system, in accordance with F 326 to F328, should be provided in engine and/or boiler rooms not fitted with the type of controls indicated in 105.

Section 2

PUMPS, WATER SERVICE PIPES, HYDRANTS AND HOSES

Total Capacity of Fire Pumps

201 In a passenger ship, the required fire pumps of F 4 are to be capable of delivering for fire fighting purposes a quantity of water not less than two-thirds of the total quantity required to be dealt with by the bilge pumps when employed for bilge pumping. (*See* E 239 for number and capacity of bilge pumps.)

The fire pumps are to be capable of developing the pressures in the fire main as required by 206.

202 In a cargo ship, the required fire pumps of F 5, other than the emergency pump (if any), are to be capable of delivering for fire fighting purposes a quantity of water not less than two-thirds of the total quantity required to be dealt with by the bilge pumps when employed for bilge pumping, except that in cargo ships the total required capacity of the fire pumps need not exceed 180 tons (180 metres^3) per hour. (*See* E 205 for number and capacity of bilge pumps.)

The fire pumps are to be capable of developing the pressures in the fire main as required by 206.

Fire Pumps

203 Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and that if they are subject to occasional duty for the transfer or pumping of fuel oil, suitable change-over arrangements are fitted.

In ships classed for navigation in ice the fire pump sea inlet valves are to be provided with ice clearing arrangements as required by H 809 and H 811.

204 Any pump designated as a fire pump (other than any emergency pump required by F 505) is to have a capacity not less than 80 per cent of the total required capacity divided by the number of required fire pumps and in any event is to be capable of delivering at least the two required jets of water. Any deficiency in capacity of one of the fire pumps is to be made good by excess capacity of the other fire pumps. These fire pumps are to be capable of supplying the fire main system under the required conditions.

Where more pumps than required are installed their capacities will be specially considered.

205 Relief valves are to be provided in conjunction with all fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

Pressure in the Fire Main

206 The fire pumps, associated piping and fire main are to be so designed that the following minimum pressures will be maintained at all hydrants under conditions where the two fire pumps required by 201 or 202 are simultaneously delivering water to the fire main of size required by 207 through adjacent nozzles of sizes required by 215.

PASSENGER SHIPS	
4,000 tons gross and over ...	45lb per square inch (3,2kg. per cm.²).
1,000 tons gross and over but under 4,000 tons gross	40lb per square inch (2,8kg. per cm.²).
Under 1,000 tons gross ...	A pressure sufficient to produce a 40 foot (12,2 metres) jet throw required by 215 to the satisfaction of the Surveyors.
CARGO SHIPS	
6,000 tons gross and over ...	40lb per square inch (2,8 kg. per cm.²).
1,000 tons gross and over but under 6,000 tons gross ...	37lb per square inch (2,6 kg. per cm.²)
Under 1,000 tons gross ...	A pressure sufficient to produce a 40 foot (12,2 metres) jet throw required by 215 to the satisfaction of the Surveyors.

Fire Main

207 The diameter of the fire main is to be based on the required capacity of two fire pumps and the diameters of the water service pipes are to be sufficient to ensure an adequate supply of water for the simultaneous operation of at least two fire hoses. In general, the diameter of the fire main should be not less than that required by the following formula but is to be in no case less than 2 inches (50 mm.):—

$$d = \frac{L}{100} + 1 \qquad d_1 = \frac{L_1}{1,2} + 25$$

When d = internal diameter of the fire main, in inches,

d_1 = internal diameter of the fire main, in millimetres,

L = rule length of the ship, in feet,

L_1 = rule length of the ship, in metres.

The diameter of the fire main need not exceed 5 inches (127 mm.) in cargo ships and 7 inches (178 mm.) in passenger ships.

208 The fire main is to be situated outside the machinery spaces and the discharge line or lines from the fire pumps are to be fitted with isolating valves at the connections to the fire main. Where the machinery space is situated amidships isolating valves are also to be provided in the fire main so that the hydrants at both ends of the ship may be used simultaneously or separately.

209 The wash deck line may be used as a fire main provided the requirements of this Section are satisfied.

210 All water pipes for fire extinguishing are to be provided with drain valves for use in frosty weather. The valves are to be located where they will not be damaged by cargo.

Number and Position of Hydrants

211 The number and position of the hydrants are to be such that at least two jets of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the ship. In ships of 1000 tons gross and over two hydrants are to be provided in the machinery spaces: in smaller ships one hydrant will be accepted.

Pipes and Hydrants

212 Materials readily rendered ineffective by heat are not to be used for fire mains. Where steel pipes are used they are to be galvanised internally and externally. Cast iron pipes are not acceptable. The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. In ships where deck cargo may be carried, the positions of the hydrants are to be such that they are always readily accessible and the pipes are to be arranged as far as practicable to avoid risk of damage by such cargo. Unless there is provided one hose and nozzle for each hydrant in the ship there shall be complete interchangeability of hose couplings and nozzles.

213 Cocks or valves are to be fitted in such positions on the pipes that any of the fire hoses may be removed while the fire pumps are at work.

Fire Hoses

214 Fire hoses are to be of leather, seamless hemp, close weave flax canvas, or other approved material. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Their length in general is not to exceed 60 feet (18,3 metres). Each hose is to be provided with a nozzle and the necessary couplings. Fire hoses, together with any

necessary fittings and tools, are to be kept ready for use in conspicuous positions near the water service hydrants or connections.

Nozzles

215 The nozzles used for extinguishing fires other than oil fires are to have a bore of not less than $\frac{1}{2}$ inch (12 mm.). For accommodation and service spaces, a nozzle size of $\frac{1}{2}$ inch (12 mm.) will normally be adequate but for machinery spaces and exterior locations $\frac{1}{2}$, $\frac{5}{8}$ or $\frac{3}{4}$ inch (12, 16 or 20 mm.) nozzles may be adopted so as to make full use of the maximum discharge capacity of the fire pumps. The jet throw at any nozzle is to be about 40 feet (12,2 metres). Dual purpose nozzles for jet or fog may be adopted.

International Shore Connection

216 The international shore connection required by F 408 and F 509 is to be suitable for a working pressure of 150 pounds per square inch (10,5 kg. per cm.^{2}). It is to have on one side a flat faced flange with dimensions as shown in Fig. 1, and on the other side a permanently attached coupling that will fit the ship's hydrants and hose. The connection is to be kept aboard the ship together with a gasket suitable for 150 pounds per square inch (10,5 kg. per cm.^{2}) service, together with four $\frac{5}{8}$ inch (16 mm.) bolts, 2 inches (50 mm.) in length, and eight washers.

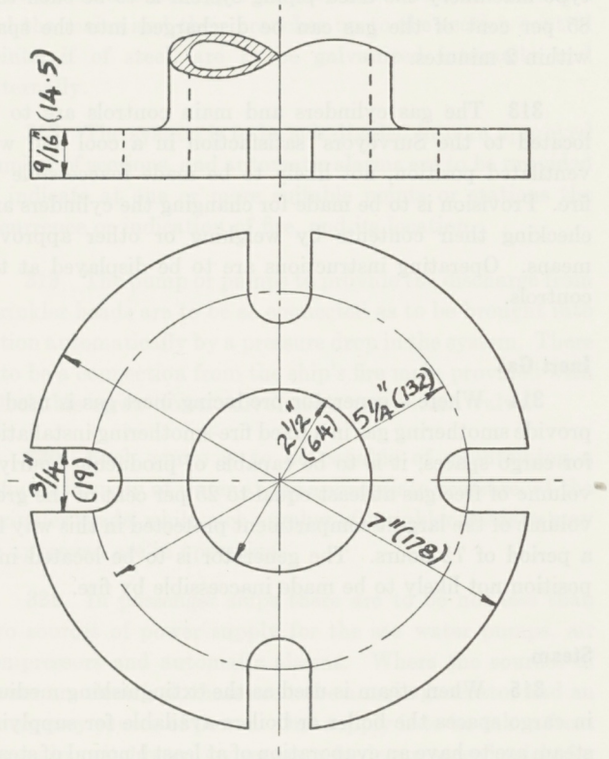


Fig. 1

Section 3

FIRE EXTINGUISHERS AND EXTINGUISHING SYSTEMS

Fire Extinguishers (Portable and Non-Portable)

301 All fire extinguishers are to be approved types. If considered necessary, the Committee may require the makers to produce evidence from a recognised independent testing authority regarding the suitability of their appliances.

302 The extinguishers required for use in the machinery spaces of ships burning oil as fuel are to be of a type discharging froth, carbon dioxide gas, dry powder, or other approved medium suitable for extinguishing oil fires.

Fire extinguishers containing an extinguishing medium which either itself or when in use gives off gases harmful to persons are not to be used. For radio rooms and switchboards extinguishers containing not more than 1 quart (1,136 litres) of carbon tetrachloride or similar media may be permitted subject to such extinguishers being additional to any required by F 4 and F 5.

303 The capacity of required portable fluid extinguishers is not to be more than 3 gallons (13,5 litres) and not less than 2 gallons (9 litres). Other extinguishers are not to be in excess of the equivalent portability of the 3 gallon (13,5 litre) fluid extinguisher and are not to be less than the fire extinguishing equivalent of a 2 gallon (9 litre) fluid extinguisher.

304 A spare charge is to be provided for each required portable fire extinguisher which can be readily re-charged on board. If this cannot be done, duplicate extinguishers are to be provided.

305 One of the portable fire extinguishers intended for use in any space is to be stowed near the entrance to that space.

Acceptable Equivalents

306

Froth	Carbon Dioxide
30 gal. (136 litres)	100 lb. (45 kg.)
10 gal. (45 litres)	35 lb. (16 kg.)
Portable	10 lb. (4,5 kg.)

Fire-Smothering Gas or Steam for Machinery and Cargo Spaces

307 Where provision is made for the injection of gas into machinery spaces or gas or steam into cargo spaces for fire extinguishing purposes, the necessary pipes for conveying the gas or steam are to be provided with control valves or cocks which are to be so placed that they will be easily accessible and not readily cut off from use by an outbreak of fire. These control valves or cocks are to be so marked as to indicate clearly the compartments to which the pipes are led. Suitable provision is to be made to prevent inadvertent admission of the gas or steam to any compartment. Where cargo spaces, fitted with smothering equipment for fire protection, are used as passenger spaces the smothering connections are to be blanked during service as a passenger space. Blank flanges fitted in gas or steam distribution pipes are to be of the "spectacle" type. The nuts for the securing bolts are to be of non-corrodible metal.

308 The piping is to be of adequate size and so arranged to provide effective distribution of fire-smothering gas or steam. In holds exceeding 60 feet (18,3 metres) in length, there are to be at least two pipes, one of which is to be fitted in the forward part and one in the after part; the steam pipes are to be led well down in the space as remote as possible from the shell. Separate pipes are to be provided for lower hold and 'tween decks. All pipes are to be arranged to be self-draining and are not to be led through refrigerated spaces unless the pipes are specially insulated. Steel distribution pipes are to be galvanised internally and externally and are not to be smaller than $\frac{3}{4}$ inch (20 mm.) bore for carbon dioxide and 1 inch (25 mm.) bore for steam and inert gas.

In tankers, the piping system is to be so arranged that the gas or steam will be distributed over the surface of the cargo. *See also* F 513.

Carbon Dioxide Gas

309 When carbon dioxide is used as the extinguishing medium in cargo spaces, the quantity of gas available is to be sufficient to give a minimum volume of free gas equal to 30 per cent of the gross volume of the largest cargo compartment in the ship which is capable of being sealed.

310 When carbon dioxide is used as an extinguishing medium for spaces containing boilers or internal combustion type machinery, the quantity of gas carried is to be sufficient to give a minimum volume of free gas equal to the larger of the following, either:—

(1) 40 per cent of the gross volume of the largest space, the volume to include the casing up to the level at which the horizontal area of the casing is 40 per cent or less of that of the space concerned; or

(2) 35 per cent of the entire volume of the largest space including the casing;

provided that the above mentioned percentages may be reduced to 35 per cent and 30 per cent respectively for cargo ships of less than 2000 tons gross; provided also that if two or more spaces containing boilers or internal combustion type machinery are not entirely separate they are to be considered as forming one compartment.

When evaluating the quantity of carbon dioxide gas required for the machinery spaces of motor ships, the free air content of the main starting air receivers is to be added to the above gross space volumes. (*See also* J 2411.)

311 When carbon dioxide is used as an extinguishing medium both for cargo spaces and for spaces containing boilers or internal combustion type machinery the quantity of gas need not be more than the maximum required either for the largest cargo compartment or machinery space. The volume of gas is to be calculated at 9 cubic feet to the pound (0,56 cubic metres to the kilogramme).

312 When carbon dioxide is used as the extinguishing medium for spaces containing boilers or internal combustion type machinery the fixed piping system is to be such that 85 per cent of the gas can be discharged into the space within 2 minutes.

313 The gas cylinders and main controls are to be located to the Surveyors' satisfaction in a cool and well ventilated position, not likely to be made inaccessible by fire. Provision is to be made for changing the cylinders and checking their contents by weighing or other approved means. Operating instructions are to be displayed at the controls.

Inert Gas

314 Where a generator producing inert gas is used to provide smothering gas in a fixed fire-smothering installation for cargo spaces, it is to be capable of producing hourly a volume of free gas at least equal to 25 per cent of the gross volume of the largest compartment protected in this way for a period of 72 hours. The generator is to be located in a position not likely to be made inaccessible by fire.

Steam

315 When steam is used as the extinguishing medium in cargo spaces the boiler or boilers available for supplying steam are to have an evaporation of at least 1 pound of steam per hour for each 12 cubic feet (1 kilogramme for each 0,75

cubic metre) of the gross volume of the largest cargo compartment in the ship. It is required that steam will be available immediately and will not be dependent on the lighting of boilers and that it can be supplied continuously until the end of the voyage in the required quantity in addition to any steam necessary for the normal requirements of the ship including propulsion and that provision is made for extra feed water necessary to meet this requirement.

Steam is not to be used in spaces containing explosives.

Steam used for fire extinguishing purposes is not to be obtained from a supply of super-heated steam.

Audible Alarms

316 Means are to be provided whereby audible warning is given automatically before fire-smothering gas can be released into the machinery space and any other working space.

Automatic Sprinkler Systems

317 Any automatic water sprinkler system for fire protection is to be designed for immediate use at any time, so that no action on the part of the crew is necessary to set it in operation. Where such a system is fitted, it is to be kept charged at the necessary pressure and is to have provision for a continuous supply of water. The distribution pipes are to be of steel or other approved material of adequate strength and the mains and their branches up to the section control points, if of steel, are to be galvanized internally and externally.

318 The system is to be sub-divided into an approved number of sections, and automatic alarms are to be provided to indicate at one or more suitable points or stations the occurrence or indication of fire, and its location.

319 The pump or pumps to provide the discharge from sprinkler heads are to be so connected as to be brought into action automatically by a pressure drop in the system. There is to be a connection from the ship's fire main provided with a lockable screw-down valve and a non-return valve.

320 Each pump is to be capable of maintaining a sufficient supply of water at the appropriate pressure, at the sprinkler heads, while such number of sprinkler heads as may be approved are in operation.

321 In passenger ships there are to be not less than two sources of power supply for the sea water pumps, air compressors and automatic alarms. Where the sources of power are electrical, these are to be a main generator and an emergency source of power. One supply is to be taken from the main switchboard by separate feeders reserved solely for that purpose. Such feeders are to be run to a change-over switch situated near to the sprinkler unit and the switch shall normally be kept closed to the feeder from the emergency switchboard. The change-over switch is to be clearly labelled, and no other switch except those at the switchboards is to be permitted in these feeders.

322 Sprinkler heads are required to operate at temperatures between 155° F. and 200° F. (68° C. and 93° C.) except in drying rooms and other hot spaces. Suitable means for the periodic testing of all automatic arrangements are to be provided.

323 Where a sprinkler system of fire protection is employed in a ship the superstructure of which is constructed in aluminium alloy, the whole unit including the sprinkler pump, tank and air compressor is to be situated in an approved position reasonably remote from the boiler and machinery spaces. If the feeders from the emergency generator to the sprinkler unit pass through any space constituting a fire risk the cables are to be of a fireproof type.

Fixed Froth Fire Extinguishing System

324 Any required fixed froth fire extinguishing system is to be able to discharge a quantity of froth sufficient to cover to a depth of 6 inches (150 mm.) the largest area over which oil fuel is liable to spread.

325 Such a system is to be controlled from an easily accessible position or positions, outside the space to be protected, which will not be readily cut off by an outbreak of fire. The distribution pipes are to be of steel galvanised internally and externally.

Fire Detection Systems

326 All required fire detection systems are to be capable of automatically indicating the presence or indication of fire and its location. Indicators are to be centralised either on the bridge or in other control stations which are provided with a direct communication with the bridge. The indicators may be distributed among several stations subject to approval by the Surveyors.

327 Electrical equipment used in the operation of required fire detection systems is to have two separate sources of power, one of which should be an emergency source.

328 The alarm system is to operate both audible and visible signals at the main stations referred to in 326. Detection systems for cargo spaces need not have audible alarms.

Fixed Pressure Water-Spraying Systems for Engine Rooms and Boiler Rooms

329 Fixed pressure water-spraying systems for boiler rooms with oil fired boilers and engine rooms with internal combustion type machinery are to be provided with spray ing nozzles of an approved type.

330 The number and arrangement of the nozzles are to be to the satisfaction of the Surveyors and be such as to ensure an effective distribution of water in the spaces to be protected. Nozzles are to be fitted above bilges, tank tops and other areas over which oil fuel is liable to spread and also above oil fuel settling and service tanks, heaters, pumping units, purifiers and other main fire hazards in the boiler and engine rooms.

331 The system may be divided into sections, the distribution manifolds of which are to be operated from easily accessible positions outside the spaces to be protected and which will not be readily cut off by an outbreak of fire.

332 The system is to be kept charged at the necessary pressure and the pump supplying the water for the system is to be put automatically into action by a pressure drop in the system.

333 The pump is to be capable of simultaneously supplying at the necessary pressure all sections of the system in any one compartment to be protected. The pump and its controls are to be installed outside the space or spaces to be protected. It is not to be possible for a fire in the space or spaces protected by the water-spraying system to put the system out of action.

334 Special precautions are to be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.

Fireman's Outfit

335 A fireman's outfit is to consist of a breathing apparatus, a lifeline, a safety lamp and an axe, as described in this paragraph.

The breathing apparatus is to be of an approved type and may be either (1) or (2):—

(1) A smoke helmet or smoke mask which is to be provided with a suitable air pump and a length of air hose sufficient to reach from the open deck, well clear of hatch or doorway, to any part of the holds or machinery spaces. If, in order to comply with this requirement, an air hose exceeding 120 feet (36,6 metres) in length would be necessary, a self-contained breathing apparatus is to be substituted or provided in addition.

(2) A self-contained breathing apparatus which is to be capable of functioning for a period of at least 30 minutes. Spare bottles are to be provided except where facilities for re-charging the bottles are available on board ship.

Each breathing apparatus is to have attached to its belt or harness, by means of a snaphook, a fireproof lifeline of sufficient length and strength.

The safety lamp (hand lantern) is to be of an approved type. Such safety lamps are to be electric, and are to have a minimum burning period of three hours.

The axe is to have an insulated handle.

Closing of Openings and Control of Fans

336 Provision is to be made for closing all openings which might admit air to machinery spaces, to other spaces where there is risk of an oil fire and to cargo spaces protected by fire-smothering systems. Skylights and ventilators of machinery spaces including pump rooms in tankers are to be capable of being shut from deck or from a safe position outside these spaces. Provision is to be made for rapidly stopping all fans from positions outside such spaces.

Cross-references

337 For precautionary arrangements relating to oil leakage and outbreaks of fire *see:*—

D 2025–D 2028, D 2216, D 2331, D 2401, E 310, E 315–E–319, E 330–E 333, E 337–E 343, E 403–E 405, E 407 and E 413–E 414.

Section 4

REQUIREMENTS FOR PASSENGER SHIPS

Fire Detection and Alarms

401 Manual fire alarms are to be fitted throughout the passenger and crew accommodation to enable the fire patrol to give an alarm immediately to the bridge or fire control station.

402 A fire alarm or fire detecting system is to be provided which will automatically indicate at one or more suitable points or stations, where it can be most quickly observed by officers and crew, the presence or indication of fire and its location in any parts of the ship such as cargo spaces, baggage and store rooms which are not accessible to the patrol system, except where the ship is engaged on voyages of such short duration that it would be unreasonable to apply this requirement.

Fire Pumps and Water Service Pipes

403 A passenger ship is to be provided with fire pumps, water service pipes, hydrants and hoses complying with F 2 and with the following requirements:—

(1) A passenger ship of 4000 tons gross and over is to be provided with at least three independently driven fire pumps and every passenger ship of less than 4000 tons gross with at least two such fire pumps.

(2) In a passenger ship of 1000 tons gross and over the arrangement of sea connections, pumps and sources of power for operating them is to be such as to ensure that a fire in any one compartment will not put all the fire pumps out of action.

(3) In a passenger ship of less than 1000 tons gross, if a fire in any one compartment could put all the pumps out of action, an emergency fire pump having a capacity of not less than 15 tons (15 metres^3) per hour is to be provided.

Fire Hydrants, Hoses and Nozzles

404 A passenger ship is to be provided with such number of fire hoses as are appropriate and sufficient for the type of ship. There is to be at least one fire hose for each of the hydrants required by F 211, and these hoses are to be used only for the purposes of extinguishing fires or testing the fire extinguishing apparatus at fire drills and surveys.

405 In accommodation, service and machinery spaces, the number and position of hydrants are to be such that the requirements of F 211 may be complied with when all watertight doors and all doors in main vertical zone fire bulkheads are closed.

406 In a passenger ship the arrangements are to be such that at least two jets of water can reach any part of any cargo space when empty.

407 All hydrants in the machinery spaces of passenger ships with oil-fired boilers, steam turbine or internal combustion type propelling machinery are to be fitted with hoses having in addition to the nozzles required in F 215 nozzles suitable for spraying water on oil, or alternatively, dual purpose nozzles. One such hydrant is to be provided in the shaft tunnel adjacent to the engine room watertight door.

International Shore Connection

408 A passenger ship of 1000 tons gross and over is to be provided with at least one international shore connection, complying with F 216. Facilities are to be available enabling such a connection to be used on either side of the ship.

Portable Fire Extinguishers in Accommodation and Service Spaces

409 A passenger ship is to be provided in accommodation, radio rooms and service spaces with such approved portable fire extinguishers as the Surveyors may deem to be appropriate and sufficient. In galleys and their sub-division, one or more portable extinguishers suitable for dealing with fires in oil-fired or electric cooking equipment are to be provided.

Fixed Fire-Smothering Arrangements in Cargo Spaces

410 The cargo spaces of passenger ships of 1000 tons gross and over are to be protected by a fixed fire-smothering gas system complying with F 3.

411 Where a passenger ship is engaged on voyages of such short duration that it would be unreasonable to apply the requirements of 410 and also in passenger ships of less than 1000 tons gross, the necessity for fire-smothering arrangements in cargo spaces will be specially considered.

Fire Extinguishing Appliances in Boiler Rooms, etc.

412 In spaces where main or auxiliary oil-fired boilers are situated, or in spaces containing oil fuel units or settling tanks, a passenger ship is to be provided with any one of the following fixed fire extinguishing installations complying with F 3:—

(1) A pressure water spraying system.

(2) A fire-smothering gas installation.

(3) A fixed froth installation supplemented, if necessary, by a fixed or mobile arrangement for pressure water or froth spraying to fight fire above the floor plates.

In each case if the engine and boiler rooms are not entirely separate, or if fuel oil can drain from the boiler room into the engine room bilges, the combined engine and boiler rooms are to be considered as one compartment.

413 There are to be at least two approved portable extinguishers discharging froth or other approved medium suitable for extinguishing oil fires, in each firing space in each boiler room and each space in which a part of the oil fuel installation is situated.

There is to be not less than one approved froth type extinguisher of at least 30 gallons (136 litres) capacity or equivalent in each boiler room. These extinguishers are to be provided with hoses on reels suitable for reaching any part of the boiler room and spaces containing any part of the oil fuel installations.

414 In each firing space there is to be a receptacle containing at least 10 cubic feet (0,28 metre^3) of sand, sawdust impregnated with soda or other approved dry material and a scoop for distributing this material. Alternatively, an approved portable extinguisher may be substituted therefor.

Fire Fighting Appliances in Spaces containing Internal Combustion Type Machinery

415 Where internal combustion engines or gas turbines are used, either (1) for main propulsion or (2) for auxiliary purposes associated with a total power not less than 1000 B.H.P., a passenger ship is to be provided with the following arrangements A and B:—

(A) There is to be one of the fixed arrangements 1, 2 or 3 required by 412.

(B) There is to be in each engine space one approved froth type extinguisher of not less than 10 gallons (45 litres) capacity or equivalent and also one approved portable froth type extinguisher for each 1000 B.H.P. of the engines or part thereof; but the total number of portable extinguishers so supplied is to be not less than two and need not exceed six.

Fire Fighting Arrangements in Spaces containing Steam Machinery

416 Provision is to be made for extinguishing lubricating oil fires in spaces which are separated from boiler rooms by watertight bulkheads when these spaces contain steam turbines or enclosed forced lubricated steam engines using superheated steam. Equipment not less effective than detailed in 415 (B) is to be provided to the Surveyors' satisfaction.

Fireman's Outfits

417 A passenger ship is to carry at least two fireman's outfits each complying with the requirements of F 335. Where the ship exceeds 10000 tons gross at least three outfits are to be carried and where it exceeds 20000 tons gross at least four outfits are to be carried. These outfits are to be kept in widely separated places ready for use.

Section 5

REQUIREMENTS FOR CARGO SHIPS

Fire Pumps and Water Service Pipes

501 All cargo ships are to be provided with fire pumps, water service pipes, hydrants and hoses complying in general with F 2.

502 In cargo ships of less than 150 tons gross, one power pump is to be available for fire extinguishing service. If the ship has a restricted class for harbour or river service a suitable hand pump may be substituted for the power pump.

503 In cargo ships of 150 tons gross and over, but less than 1000 tons gross, not less than two power pumps are to be provided, one of which is to be an independent pump.

504 In cargo ships of 1000 tons gross and over not less than two independently driven power pumps are to be provided.

505 In a cargo ship of 1000 tons gross and over if a fire in any one compartment could put all the pumps out of action there is to be an alternative means of providing water for fire fighting. This alternative means is to be a fixed emergency pump independently driven by a compression ignition engine, or other approved means and having a capacity of not less than 15 tons (15 metres^3) per hour in ships of 1000 tons gross to 2000 tons gross, and not less than 25 tons (25 metres^3) per hour for ships above 2000 tons gross. This emergency pump is to be capable of supplying two jets of water to the satisfaction of the Surveyors. The pump should be located remote from the machinery space; e.g. in ships with machinery amidships the pump should be installed in the tunnel or steering gear compartment, and in ships with machinery aft the pump preferably should be located forward. The pump is to be provided with its own sea suction and a discharge to the fire main. The suction lift is not to exceed 20 feet (6 metres) with the ship in light draught. The fuel service tank for the engine is to have a capacity for at least 3 hours operation of the emergency pump. In addition sufficient fuel is to be available for at least 12 hours operation of this pump.

Fire Hydrants, Hoses and Nozzles

506 In cargo ships the number of fire hoses to be provided, each complete with couplings and nozzles, is to be one for each 100 feet (30 metres) length of the ship and one spare, but in no case less than five in all for cargo ships of 1000 tons gross and over and three in all for smaller ships. These numbers do not include any hoses required in any engine or boiler room. If necessary the number of hoses is to be increased so as to ensure that hoses in sufficient number are available and accessible at all times, having regard to the type of the ship and the nature of the trade on which the ship is employed.

507 In accommodation, service and machinery spaces, the number and position of hydrants are to be such as to

comply with the requirements of F 211. In a cargo ship the arrangements are to be such that at least two jets of water can reach any part of any cargo space when empty.

In ships of 2000 tons gross and over a hydrant is to be provided in the shaft tunnel adjacent to the engine room watertight door.

508 All hydrants in the machinery spaces of cargo ships with oil fired boilers or internal combustion type propelling machinery are to be fitted with hoses having in addition to the nozzles required in F 215 nozzles suitable for spraying water on oil, or alternatively, dual purpose nozzles.

International Shore Connection

509 A cargo ship of 1000 tons gross and over is to be provided with at least one international shore connection, complying with F 216. Facilities are to be available enabling such a connection to be used on either side of the ship.

Portable Fire Extinguishers in Accommodation and Service Spaces

510 A cargo ship is to be provided in accommodation, radio rooms and service spaces with a sufficient number of portable fire extinguishers to ensure that at least one extinguisher will be readily available for use in every compartment of the crew and passenger spaces to the Surveyors' satisfaction; in any case, their number is not to be less than five for ships of 1000 tons gross and over and not less than three in ships of under 1000 tons gross.

For galleys and for spaces containing domestic boilers one portable fire extinguisher suitable for dealing with oil fires or fires in electric cooking equipment is to be provided.

Where a sprinkler system is installed the arrangements will be specially considered.

Fixed Fire Smothering Arrangements in Cargo Spaces

511 Cargo spaces of ships of 2000 tons gross and over are to be protected by a fixed fire smothering system using carbon dioxide, inert gas or steam. The arrangements are to comply with F 3.

512 The requirements of paragraph 511 may be waived for the cargo holds of any ship (other than the tanks of a tanker):—

(1) If they are provided with steel hatch covers having fireproof joints and effective means of closing all ventilators and other openings leading to the holds; or

(2) if the ship is constructed and intended solely for carrying such cargoes as ore, coal or grain; or

(3) where the ship is engaged on voyages of such short duration that it would be unreasonable to apply the requirement.

513 The cargo tanks of tankers of 500 tons gross and over are to be protected by a fixed fire smothering system using carbon dioxide, steam or froth. Installations discharging froth externally to the tanks may be accepted. The details of such installations are to be to the satisfaction of the Surveyors (for steam system *see* E 1119).

514 The cargo tanks of liquefied gas carriers are to be protected by a fixed fire smothering gas system and/or dry chemical extinguishing system. Details are to be submitted for approval.

Fire Detection in Cargo Spaces

515 A smoke or fire detection system is to be provided in each cargo space containing explosives and in adjacent cargo spaces.

Fire Extinguishing Appliances in Boiler Rooms, etc.

516 In spaces where main or auxiliary oil-fired boilers are situated, or in spaces containing oil fuel units or settling tanks, a cargo ship is to be provided with any one of the following fixed fire extinguishing installations complying with F 3.

(1) A pressure water spraying system.

(2) A fire-smothering gas installation.

(3) A fixed froth installation supplemented, if necessary, by a fixed or mobile arrangement for pressure water or froth spraying to fight fire above the floor plates.

The fixed installation is to be of type (2) above in all cases where the flash point of the oil fuel is less than 150° F. (65,5°C.) or where methane gas is used as fuel for the propulsion of methane tankers. (*See* Chapter R (A).)

In each case if the engine and boiler rooms are not entirely separate, or if fuel oil can drain from the boiler room into the engine room bilges, the combined engine and boiler rooms are to be considered as one compartment.

517 There are to be at least two approved portable extinguishers discharging froth or other approved medium suitable for extinguishing oil fires in each firing space in each boiler room and each space in which a part of the oil fuel installation is situated. In addition, there is to be at least one extinguisher of the same description with a capacity of 2 gallons (9 litres) for each burner, provided that the total capacity of the additional extinguisher or extinguishers need not exceed 10 gallons (45 litres) for any one boiler room.

518 In each firing space there is to be a receptacle containing at least 10 cubic feet (0,28 metre^3) of sand, sawdust impregnated with soda, or other approved dry material and a scoop for distributing this material. Alternatively, an approved portable extinguisher may be substituted therefor.

Fire Fighting Appliances in Spaces containing Internal Combustion Type Machinery

519 Where internal combustion engines or gas turbines are used, either (1) for main propulsion machinery, or (2) for auxiliary purposes associated with a total power not less than 1000 B.H.P., a cargo ship of 1000 tons gross and over is to be provided with the following arrangements A and B, and a cargo ship of under 1000 tons gross with arrangement B. For cargo ships of under 150 tons gross the provision of a 10 gallon (45 litre) extinguisher may be waived.

(A) There is to be one of the fixed arrangements 1, 2 or 3 required by paragraph 516.

(B) There is to be in each engine space one approved froth type extinguisher of not less than 10 gallons (45 litres) capacity or equivalent and also one approved portable froth extinguisher for each 1000 B.H.P. of the engines or part thereof; but the total number of portable extinguishers so supplied is not to be less than two and need not exceed six.

Fire Fighting Arrangements in Spaces containing Steam Machinery

520 Provision is to be made for extinguishing lubricating oil fires in spaces which are separated from boiler rooms by watertight bulkheads when these spaces contain propulsion turbines or enclosed forced lubricated engines using superheated steam. Equipment not less effective than detailed in arrangement B of 519 is to be provided to the Surveyors' satisfaction.

Fire Fighting Arrangements in Pump Rooms and Compressor Rooms of Tankers

521 The cargo pump rooms in tankers of 500 tons gross and over are to be provided with a fixed, deck operated, fire extinguishing system using steam, water spray, carbon dioxide or other suitable medium.

In addition, two portable foam extinguishers or equivalent are to be provided, one at the pumps and one at the pump room entrance.

522 The cargo pump rooms and compressor rooms in liquefied gas carriers of 500 tons gross and over are to be provided with a fixed remote controlled fire extinguishing system using carbon dioxide or other suitable medium.

In addition, two portable dry chemical extinguishers or equivalent are to be provided in each space.

523 In tankers and liquefied gas carriers of less than 500 tons gross the fire extinguishing arrangements are to be to the satisfaction of the Surveyors.

Fireman's Outfits

524 A cargo ship is to carry at least one fireman's outfit complying with the requirements of F 335. Ships of 4000 tons gross and over are to carry two such outfits which are to be located at widely separated positions.

Section 6

REQUIREMENTS FOR SHIPS NOT FITTED WITH PROPELLING MACHINERY

601 A power pump or hand pump is to be fitted having a suction from the sea and a discharge to deck for fire extinguishing purposes.

Where oil fuel is used for the generation of power, fire extinguishing appliances suitable for fighting oil fires are to be provided to the satisfaction of the Surveyors.

PART 2

FIRE PROTECTION IN PASSENGER, CARGO AND OTHER SHIPS

Section 7

GENERAL

701 Except where otherwise stated, the requirements of Part 2 of this Chapter apply to passenger ships carrying more than 36 passengers, and cargo ships of 4000 tons gross and over, to be classed for unrestricted service.

702 While the requirements satisfy the regulations of the International Convention for the Safety of Life at Sea, 1960, attention should also be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered. Compliance with these statutory requirements may be accepted as meeting the requirements of this Chapter.

703 Consideration will be given to special cases where the arrangements are equivalent to those required by these Rules. Consideration will also be given to fire protection arrangements in ships to be classed for restricted or special services.

704 Plans showing the proposed arrangements are to be submitted for approval.

Materials

705 The hull, superstructures, bulkheads, decks and deckhouses are to be of steel or other material which, by itself or due to insulation provided, has structural and fire integrity properties equivalent to steel. In cargo ships the use of other suitable material will be specially considered.

706 Pipes conveying oil or combustible liquids are to be of approved material having regard to the fire risk. Materials readily rendered ineffective by heat are not to be used for overboard scuppers, sanitary discharges and other outlets which are close to the water line and where the failure of the material in the event of fire would give rise to dangers of flooding.

Section 8

REQUIREMENTS FOR PASSENGER SHIPS CARRYING MORE THAN 36 PASSENGERS

Main Vertical Fire Zones and Fire Divisions

801 The hull, superstructures and deckhouses are to be sub-divided into main vertical fire zones, the mean length of which on any one deck does not in general exceed 131 feet (40 metres), by "A" Class fire-resisting divisions as defined in the Safety Convention. Steps and recesses are to be kept to a minimum and are to be of "A" Class divisions.

As far as practicable, the bulkheads forming the boundaries of the main vertical fire zones above the bulkhead deck are to be in line with watertight sub-division bulkheads situated immediately below. Such bulkheads are to extend from deck to deck and to the shell or other boundaries.

Openings in "A" Class Fire-Resisting Divisions

802 Where "A" Class divisions are pierced for electric cables, pipes, trunks, ducts, girders, beams, etc., arrangements are to be made to ensure that the fire resistance is not impaired.

803 Dampers are to be fitted in ventilation trunks and ducts passing through main vertical fire zone bulkheads and are to have local control capable of operation from both sides of the bulkhead. The operating positions are to be readily accessible and marked in red lettering. Indicators are to be fitted to show whether the dampers are open or shut.

804 Except for tonnage openings and hatches to cargo, store and baggage spaces, all openings are to be provided with permanently attached means of closing which are to be at least as effective for resisting fires as the divisions in which they are fitted. Where "A" Class divisions are pierced by tonnage openings the means of closure are to be steel plates.

805 Doors and door frames in "A" Class divisions, with the means of securing them closed, are to provide resistance to fire and to the passage of smoke and flame equivalent to that of the bulkheads in which the doors are situated. Watertight doors need not be insulated.

Each door is to be capable of being opened from each side of the bulkhead by one person only. Fire doors in main vertical zone bulkheads other than watertight doors, are to be of the self-closing type with simple and easy means of release from the open position. These doors are to be of approved type, and the self-closing mechanism is to be capable of closing the door against an inclination of $3\frac{1}{2}$ degrees opposing closure.

Bulkheads within Main Vertical Fire Zones

806 In ships in which Safety Convention Method I or III fire protection arrangement is adopted, and in which an automatic sprinkler system is not to be fitted, the enclosure bulkheads within accommodation spaces, other than those required to be "A" Class fire-resisting divisions, are to be constructed of "B" Class fire-retarding divisions as defined in the Safety Convention. The arrangement of fire-retarding divisions will be specially considered in relation to the method of fire protection adopted.

Accommodation spaces are halls, dining rooms, lounges and similar permanently enclosed spaces, corridors, lavatories, cabins, offices, crew's quarters, barber shops, isolated pantries and lockers and similar spaces.

Separation of Accommodation Spaces from Machinery, Cargo and Service Spaces

807 The boundary bulkheads and decks separating accommodation spaces from machinery, cargo and service spaces are to be "A" Class fire-resisting divisions, the insulating value of which will be specially considered having regard to the nature of the adjacent spaces.

Machinery spaces include all spaces used for propelling, auxiliary or refrigerating machinery, boilers, pumps, workshops, generators, steering gear, ventilation and air conditioning machinery, oil filling stations and similar spaces and trunks to such spaces.

Service spaces are galleys, main pantries, stores, (except isolated pantries and lockers), mail and specie rooms and similar spaces and trunks to such spaces.

Primary deck coverings within accommodation spaces, control stations, stairways and corridors are to be of approved material which will not readily ignite.

Protection of Stairways in Accommodation and Service Spaces

808 Stairways in accommodation and service spaces are to be of steel frame or other approved equivalent construction and are to be within enclosures formed of "A" Class divisions with positive means of closure at all openings from the lowest accommodation deck at least to a level which is directly accessible to the open deck, except that:—

(1) a stairway connecting only two decks need not be enclosed, provided the integrity of the deck is maintained by proper bulkheads or doors at one level;

(2) stairways may be fitted in the open in a public space, provided they lie wholly within such public space.

Stairway enclosures are to have direct communication with the corridors and are to be of sufficient area to prevent congestion having in view the number of persons likely to use them in an emergency, and are to contain as little accommodation, or other enclosed space in which a fire may originate, as practicable.

The insulation value of stairway enclosure bulkheads will be specially considered having regard to the nature of the adjacent spaces. The means for closure at openings in stairway enclosures are to be at least as effective for resisting fire as the bulkheads in which they are fitted. Doors other than watertight doors are to be of the self-closing type, as required for the main vertical fire zone bulkheads in accordance with 805.

The construction and protection of auxiliary stairways which do not form part of the general means of escape will be specially considered.

Protection of Lift Trunks, Light and Air Trunks, Control Stations and Storerooms, etc.

809 Passenger and service lift trunks, vertical trunks for light and air to passenger spaces, etc., are to be of "A" Class fire-resisting divisions. Doors are to be of steel or other equivalent material and when closed are to provide fire resistance at least as effective as the trunks in which they are fitted.

Lift trunks are to be so fitted as to prevent the passage of smoke and flame from one 'tween deck to another and are to be provided with means of closing so as to permit of draught and smoke control. Insulation need not be fitted to lift trunks which are within stairway enclosures.

Where a trunk for light and air communicates with more than one 'tween deck space and where smoke and flame are likely to be conducted from one 'tween deck to another, smoke shutters, suitably placed, are to be fitted so that each space can be isolated in case of fire.

Any other trunk (e.g. for electric cables) are to be so constructed as not to afford passage for fire from one 'tween deck or compartment to another.

810 Control stations are to be separated from the remainder of the ship by "A" Class bulkheads and decks.

Control stations are those spaces in which radio, main navigating or central fire-recording equipment or the emergency generator is located.

811 The boundary bulkheads of baggage rooms, mail rooms, store rooms, paint and lamp lockers, galleys and similar spaces are to be of "A" Class divisions. Spaces containing highly inflammable stores are to be so situated as to minimise the danger to passengers or crew in the event of fire.

Superstructures

812 Superstructures of aluminium alloy will be specially considered in relation to the Safety Convention Method of fire protection adopted. Where the use of aluminium alloy is approved:—

(1) Adequate provision is to be made to ensure that, in the event of fire, arrangements for stowage, launching and embarkation into lifeboats and rafts remain as effective as if the superstructures were constructed of steel; and

(2) Crowns and casings of boiler and machinery spaces are to be of steel adequately insulated, and any openings therein suitably arranged and protected to prevent spread of fire.

(*See* F 323.)

Windows and Sidescuttles

813 All windows and sidescuttles in bulkheads separating accommodation spaces and the weather are to be constructed with metal frames. The glass is to be retained by a metal glazing bead.

814 In spaces containing main propulsion machinery, or oil-fired boilers, or auxiliary internal combustion type of machinery to total horse power of 1,000 or over, the following provisions are to be made:—

(1) skylights are to be capable of being closed from outside the space.

(2) skylights containing glass panels are to be fitted with external shutters of steel or other equivalent material permanently attached.

(3) any windows in casings of such spaces are to be of non-opening type and are to be fitted with external shutters of steel or other equivalent material permanently attached.

(4) in the windows and skylights referred to above, wire-reinforced glass is to be used.

Ventilation Systems

815 The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the space in the event of fire. In general, the ventilation fans are to be so disposed that the ducts reaching the various spaces remain within the same main vertical zone.

816 All power ventilation, except cargo and machinery space ventilation, is to be fitted with master controls so that all fans may be stopped from either of two separate positions situated as far apart as practicable. Two master controls are to be provided for the power ventilation serving machinery spaces, one of which can be operated from a position outside the machinery space.

817 Efficient insulation is to be provided for exhaust ducts from galley ranges where the ducts pass through accommodation spaces.

Incombustible Materials

818 In ships in which Safety Convention Method I fire protection arrangement is adopted, and in which an automatic sprinkler system is not to be fitted, all linings, grounds, ceilings and insulations are to be of incombustible materials except in cargo spaces, mail rooms, baggage rooms, or refrigerated compartments of service spaces.

819 In ships in which Safety Convention Method III fire protection arrangement is adopted, and in which an automatic sprinkler system is not to be fitted, the use of combustible materials of all kinds such as untreated wood, veneers, ceilings, curtains, carpets, etc., is to be reduced as far as practicable. In large public spaces, the grounds and supports to the linings and ceilings are to be of steel or equivalent material. All exposed surfaces in corridors or stairway enclosures and concealed or inaccessible spaces shall have low flame-spread characteristics.

Automatic Sprinkler and Fire Alarm and Detection Systems

820 In ships in which Safety Convention Method II fire protection arrangement is adopted, and in which "B" Class fire-retarding divisions are not to be fitted within accommodation spaces, an automatic sprinkler and fire alarm system of an approved type, and complying with the requirements of F 317 to F 323, is to be installed and so arranged as to protect all enclosed spaces appropriated to the use or service of passengers or crew, except spaces which afford no substantial fire risk. (*See* M 507.)

Automatic Fire Alarm and Fire Detection Systems

821 In ships in which Safety Convention Method III fire protection arrangement is adopted and in which an automatic sprinkler is not to be fitted, a fire-detecting system of an approved type is to be installed and so arranged as to detect the presence of fire in all enclosed spaces appropriated to the use or service of passengers or crew (except spaces which afford no substantial fire risk), and automatically to indicate at one or more points or stations where it could be most quickly observed by officers and crew, the presence or indication of fire and also its location.

Miscellaneous Items

822 In all parts of the ship, paints, varnishes and similar preparations having a nitro-cellulose or other highly inflammable base are not to be used.

823 In all parts of the ship, pipes penetrating "A" or "B" Class fire divisions are to be of approved material having regard to the temperature such fire divisions are required to withstand.

824 In accommodation and service spaces, air spaces enclosed behind ceilings, panellings or linings are to be suitably sub-divided by close-fitting draught stops not more than 45 feet (13,7 metres) apart. In the vertical direction, such spaces including those behind linings of stairways, trunks, etc., are to be closed at each deck. Small holes are to be arranged in ceilings and bulkheading, so that it will be possible, without impairing the efficiency of the fire protection, for the fire patrols to detect any smoke originating in concealed and inaccessible spaces. The concealed surfaces of all bulkheads, linings, panellings, stairways, wood grounds, etc., in accommodation spaces are to have low flame-spread characteristics.

Section 9

PASSENGER SHIPS CARRYING NOT MORE THAN 36 PASSENGERS

901 Passenger ships to be classed for unrestricted service and carrying more than 12 passengers but not more than 36 passengers need comply only with the fire protection requirements in F 705, F 706, F 801 to F 805, F 807, F 809 (first sub-paragraph), F 810 to F 815, F 822 and F 823.

902 In addition, the following provisions shall apply:—

(i) All stairways and means of escape in accommodation and service spaces shall be of steel or other suitable material.

(ii) Power ventilation of machinery spaces shall be capable of being stopped from an easily accessible position outside the machinery spaces.

(iii) Except where all enclosure bulkheads in accommodation spaces conform with the requirements in F 806, an automatic fire detection system conforming with F 402 is to be provided.

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Section 10

REQUIREMENTS FOR CARGO SHIPS OF OVER 4000 TONS GROSS

Corridor Bulkheads in Accommodation

1001 The corridor bulkheads in accommodation spaces are to be of steel or constructed of "B" class panels. The requirements of "B" class panels are specified in Chapter II Regulation 35 of the Safety of Life at Sea Convention 1960.

Protection of Interior Stairways, Lift Trunks, Galleys, Storerooms, etc.

1002 Interior stairways below the weather deck are to be of steel or other suitable material. Lift trunks within accommodation spaces shall be of steel or equivalent material. Bulkheads of galleys, paint stores, lamp rooms, boatswain's stores when adjacent to accommodation spaces and emergency generator rooms, if any, shall be of steel or equivalent material.

Deck Coverings

1003 Deck coverings within accommodation spaces on the decks forming the crown of machinery and cargo spaces shall be of a type which will not readily ignite.

Ventilation Systems

1004 Means shall be provided for stopping ventilating fans serving machinery and cargo spaces and for closing all doorways, ventilators, annular spaces around funnels and other openings to such spaces. These means shall be capable of being operated from outside such spaces in case of fire.

Paints, etc.

1005 In accommodation and machinery spaces, paints, varnishes and similar preparations having a nitro-cellulose or other highly inflammable base are not to be used.

Section 11

REQUIREMENTS FOR CARGO SHIPS OF 500 TONS TO 4000 TONS GROSS

1101 F 1004 is to be complied with.

Chapter G

CONDITIONS FOR SURVEY OF MACHINERY DURING CONSTRUCTION

Section 1

101 The materials used in the construction of the machinery, boilers and pressure vessels are to comply with the requirements of Chapter P. Materials, for which provision is not made in Chapter P, may be accepted after compliance with such tests as may be imposed, under specifications to be approved before the materials are ordered and construction is commenced.

The machinery, boilers and pressure vessels are to be inspected throughout, the boilers and pressure vessels tested by hydraulic pressure, and the machinery tested under full power working conditions by the Society's Engineer Surveyors, who will furnish a report to the Committee. If found satisfactory, the Committee will thereupon grant a certificate, and insert in the Register Book the appropriate class notation, as set forth in Chapter B, indicating that the machinery, boilers and pressure vessels are certified to have been in good order and safe working condition on that date.

102 In cases of machinery which has been built under Special Survey, the distinguishing mark ✠ will be inserted before the appropriate class notation, as set forth in Chapter B.

103 In ships built under Special Survey, the following items of machinery are also to be constructed under Special Survey:—

The main and auxiliary engines and boilers, superheaters, economisers (including press boilers and similar apparatus for floating whale-oil factories), steering engines, air receivers, air compressors, scavenge blowers and superchargers, oil fuel burning units, feed pumps, circulating and cooling water pumps, fire and bilge pumps, air pumps, ballast and oil fuel transfer pumps, water extraction pumps, lubricating oil pumps, fuel valve cooling pumps for oil engines, forced and induced draught fans, evaporators, distiller units, feed water heaters and pressure filters where the foregoing are intended for essential services and domestic boilers intended for working pressures exceeding 3,5 kg. per cm.^{2} and having heating surfaces greater than 4,65 m^2.

Generators of 100 kW and over and motors of 100 h.p. and over intended for essential services.

Motors intended for coupling to fans for the circulation of air in refrigerated cargo spaces.

Electric slip couplings.

All electric propelling machinery including switchgear, control gear, cables, main and auxiliary generators, motor and exciters.

NOTE.—Auxiliary boilers supply steam to auxiliary services essential to the operation of the ship at sea; but do not supply steam to the main propelling machinery.

Domestic boilers supply steam for purposes not connected in any way with the operation of the ship at sea.

104 In order to facilitate the inspection, plans in triplicate of the following items, together with the necessary particulars of the machinery, including the maximum power and the revolutions per minute, are to be submitted for consideration before the work is commenced:—

Boilers, superheaters and economisers.

Air receivers.

Crank, thrust, intermediate and screw shafting and screw shaft oil gland.

Clutch and reversing gear with methods of control and flexible coupling.

Reduction gearing. (*See also* H 503.)

Propeller (including spare propeller if supplied).

General arrangement of shafting showing relative positions of the main engines, flywheel, flexible coupling, gearing, thrust block, line shafting and bearings, stern tube, "A" bracket and propeller, whichever is applicable.

NOTES—Plans additional to the above should not be submitted unless the machinery is of a novel or special character affecting classification.

For Plans of Pumping and Piping required to be submitted, *see* E 101.

For Steam and Gas Turbines, *see* H 407.

For Welded Structures for Steam Reciprocating and Oil Engines, *see* H 902.

For Welded Pressure Vessels, *see* J 1806.

For Electrical Equipment and Electric Propelling Machinery, *see* M 102.

For Refrigerated Cargo Installations, *see* N 202.

105 Where it is proposed to depart from the requirements of the Rules, the Committee will be prepared to give consideration to the circumstances of any special case.

106 Any novelty in the construction of the machinery boilers or pressure vessels is to be reported to the Committee.

107 The Surveyors are to examine and test the materials and workmanship from the commencement of the work until the final test of the machinery under full power working conditions; any defects, etc., are to be pointed out as early as possible.

Where strict adherence to normal survey procedure is impracticable as regards the material testing and hydraulic testing of small mass produced components, the Surveyors may adapt their survey to the system of production provided they can verify by sampling, check tests or other means that there is reasonable compliance with Rule requirements or equivalents. Before consideration is given to any special arrangements of this nature, it will be necessary for the Surveyors to visit the Firms' Works and satisfy themselves as to the procedure employed for the identification and quality control of materials and for inspecting and testing components during manufacture.

108 The Surveyors may also, if requested, compare the work as it progresses with the requirements of the specification agreed upon by the parties concerned, and certify to the conditions thereof, as far as can be seen, being satisfactorily complied with.

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109 The machinery and boilers are to be securely fixed to the ship's structure to the satisfaction of the Surveyor. The bed plates, gear cases, thrust blocks and boiler fastenings are to be of robust construction.

110 Refrigerating machinery using a toxic or inflammable refrigerant, such as ammonia, is to be installed in an efficiently ventilated compartment isolated from the propelling machinery spaces and shaft tunnels, and living quarters.

Methyl chloride refrigerant is not to be used.

Machinery using non-toxic and non inflammable refrigerants will not be subject to restriction on location in general, but proposals to install relatively large plants in propelling machinery spaces will require special consideration.

111 Where it is proposed to apply centralised, bridge, or automatic controls to propulsion machinery and essential auxiliaries, refrigerated cargo installations, tanker pumping systems, etc., a description of the scheme is to be submitted in order that the effect of these arrangements on the safety of the ship and machinery and the preservation of the cargo may be assessed. Particulars are to be given of the spare gear to be carried for machinery and control gear and whether maintenance is to be by repair or replacement.

When the engine and/or boiler rooms are not intended to be continuously manned at sea, an approved fire detection system is to be fitted in these spaces (*see* F 105).

Controls essential for the safe operation of the ship and preservation of the cargo are to be proved at the sea trials to the Surveyor's satisfaction.

Cross-references

112 For conditions relating to the survey during construction of Electrical Equipment, Electrical Propelling Machinery and Refrigerating Machinery and Appliances, *see* M 1, M 17 and N 1 respectively.

Chapter H

MAIN AND AUXILIARY ENGINES AND GEARING

Section 1

GENERAL REQUIREMENTS

Materials

101 Shafts, webs of built crankshafts and other important machinery parts are to be made and tested in accordance with the requirements of Chapter P or, in special cases, with an approved specification, under the supervision of the Surveyors.

102 Where it is proposed to use non-ferrous metal for shafting, details of the specification and method of manufacture are to be submitted for consideration.

Inspection

103 The surfaces of shafting and other important machinery parts are to be examined when finish machined and, if required by the Surveyors, also in the rough machined condition.

Alignment Gauges

104 All main and auxiliary oil engines exceeding 300 b.h.p. and all main steam reciprocating engines are to be provided with alignment gauges which may be either a bridge gauge or a micrometer clock gauge for use between the crank webs.

Only one micrometer clock gauge, suitable for all the engines, need be supplied for each ship.

Main and auxiliary steam turbines are to be provided with gauges of an approved type for testing the alignment of the rotor, pinion and gear wheel shafts.

Wear down gauges and turbine alignment gauges should be adjusted in the presence of the Surveyor.

Operating Conditions and Power Ratings

105 In the following sections of this Chapter where shaft dimensions are determined on power and revolutions, the values for use in the relevant formulæ are to be taken as the maximum propulsion power and revolutions for which the ship and machinery are to be classed (i.e. the maximum power which the shipowner intends to use in service).

106 Auxiliary engines coupled to electrical generators are to be capable under service conditions of developing continuously the power to drive the generators at full rated output (K.W.) and of developing for a short period (15 mins.) an overload power of 10 per cent (*see* M 106, M 403 and M 404).

NOTE. The rating of main and essential auxiliary machinery intended for installation in seagoing ships to be classed for unrestricted (geographical) service should be based on a sea temperature not less than 30° C. and an engine room ambient temperature not less than 45° C. In the case of ships to be classed for restricted service, the rating should be suitable for the temperature conditions associated with the geographical limits of the restricted service. (*See* B 109 and B 110.)

Definitions

107 Where horse power appears in this Chapter it is to be taken as 76 m. kg. per second.

Cross-References

108 For means of escape from machinery spaces and communication between bridge and engine room, *see* D 2216 and D 2217.

Section 2

STEAM RECIPROCATING ENGINES

Dimensions of Shafts

201 The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 44–52 kg. per mm.^{2} are to be of not less diameters than those given by the following formulæ.

Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Torsional Vibrations

202 The formulæ do not, however, take into consideration the possibility of severe torsional vibration stresses arising in the shafting. Where engines have cylinders of uniform diameter and in other types of engines where experience indicates that serious critical speeds might occur within or near the range of working speeds, calculations of the torsional vibration characteristics, including 1-node natural frequency tables, for the complete shafting system, are to be submitted for consideration, together with plans of all shafting and of the propeller.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

These calculations are not required to be submitted for engines other than these special cases; they may, however, be submitted voluntarily, if desired.

The Committee will accept intermediate shafts with a diameter 5 per cent less than required by the Rule formulæ, in all cases where calculations confirm that the shafting systems are free from excessive vibration stress or would be satisfactory with a barred speed range.

This 5 per cent reduction in diameter will be limited to the intermediate shafts only and will not be applicable to the sizes of couplings and their bolts.

Where serious critical speeds are found by calculation to occur within the range of working speeds, the Committee may require torsiograph records to be taken from the machinery, for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the stresses are considered to be excessive.

Intermediate Shaft

203 The diameter of the intermediate shaft is not to be less than that given by the following formula:—

Diameter of intermediate shaft, in millimetres=

$$\sqrt[3]{\frac{D^2 \times S \times WP \times 14{,}22}{C\left(\frac{D^2}{H^2}+2\right)}}$$

where WP=working pressure at the boiler outlet, in kg. per cm^2.

NOTE.—The working pressure at the boiler outlet is the pressure as controlled by boiler or superheater safety valves and as defined in E 512.

D = diameter of the low pressure cylinder, in millimetres, or the equivalent diameter where two or more low pressure cylinders are fitted,

H = diameter of the high pressure cylinder, in millimetres,

S = length of stroke, in millimetres,

C is a coefficient given in the following Table:—

Compound, triple or quadruple expansion reciprocating engines	Values of C
2 cranks at 90°	1900
2 cranks at 180°	1350
3 cranks at 120°	2150
4 cranks balanced... ...	2150
4 cranks at 90°	2100

NOTE:—The rule diameter of the intermediate shaft may be reduced by 3,5 per cent for ships classed exclusively for smooth water service and by 1,75 per cent for ships classed exclusively for service on the Great Lakes.

For the diameter of the intermediate shafting of steam reciprocating engines combined with exhaust steam turbines, *see* H 303.

Crank Shaft

204 The diameter of the crank shaft is not to be less than 1,05 times that required for the intermediate shaft, as determined by 203.

Crank Webs of Solid Forged Shafts

205 In solid forged shafts the breadth of the webs should not be less than 1,33 times and the thickness not less than 0,56 times the diameter required for the crank shaft or, if these proportions are departed from, the webs are to be of equivalent strength.

Crank Webs of Built Shafts

206 The dimensions of the crank webs of built shafts should not be less than those given by the following formulæ:—

$$h = 0{,}625 \times d$$

$$t = \sqrt{\frac{0{,}12 \times d^3}{h}}$$

where h = thickness of the web, measured parallel to the axis, in millimetres,

t = thickness of metal around the eyeholes, measured radially, in millimetres,

d = diameter required for the crank shaft, in millimetres.

If these proportions are departed from, the webs are to be of equivalent strength.

207 Reference marks are to be provided on the outer junction of the crank webs with the journals and crank pins.

Shrinkage Allowance

208 Crank webs are to be securely shrunk on the journals and crank pins. If dowels are not fitted at the junction of the journals and webs, the yield point of the material of the webs is to be not less than 22 kg. per mm.^{2}, and the shrinkage allowance is to be between $\frac{1}{550}$ and $\frac{1}{700}$ of the diameter of the shaft.

Fillets and Oil Holes

209 Fillets at the junctions of crank webs with crank pins or journals, where these are formed as solid forgings or castings, are to be machined to a smooth radius.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

Thrust Shaft

210 The diameter at the collars of the thrust shaft transmitting torque is not to be less than 1,05 times that required for the intermediate shaft as determined by 203. Outside the collars the diameter may be tapered down to that required for the intermediate shaft.

Tube Shaft

211 The diameter of the tube shaft which passes through the stern tube but does not carry the propeller, is not to be less than 1,05 times that required for the intermediate shaft as determined by 203, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1,075 times the diameter required for the intermediate shaft as determined by 203.

Screw Shaft

212 The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in millimetres} = d + \frac{P}{C}$$

where d = diameter required for the intermediate shaft, in millimetres, as determined by 203,

P = diameter of the propeller, in millimetres,

C = 144 when the shaft is fitted with a continuous liner,
100 when the shaft is not fitted with a continuous liner.

213 Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1,05 times that required for the intermediate shaft.

Hollow Shafts

214 Where the thrust, intermediate, tube and screw shafts have central holes, the dimensions of the shafts as determined by the foregoing formulæ need not be increased, provided the diameter of the central hole in a shaft does not exceed one-third of the shaft diameter.

Bronze Liners on Shafts

215 The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less, when new, than that given by the following formula:—

$$t = \frac{d + 235}{32}$$

where t = thickness of the liner, in millimetres,

d = diameter required for the screw or tube shaft under the liner, in millimetres.

216 The thickness of a continuous liner between the bushes is not to be less than 0,75 t.

217 Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner. (*See* H 621).

218 Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

219 If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

220 Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

Stern Bush

221 The length of the bearing in the stern bush next to and supporting the propeller is not to be less than four times the diameter required by rule for the screw shaft under the liner.

Coupling Bolts

222 With coupling bolts of ordinary mild steel having a minimum tensile strength of 44 kg. per mm.^{2}, the diameter of the bolts at the joining faces of the couplings is not to be less than that given by the following formula:—

$$\text{Diameter of coupling bolts, in millimetres} = \sqrt{\frac{d^3}{3{,}5 \times n \times r}}$$

where d = diameter required for the intermediate shaft, in millimetres, as determined by 203 or H 303, whichever is applicable,

n = number of bolts in the coupling,

r = radius of the pitch circle of the bolts, in millimetres.

Couplings

223 The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts at the face of the coupling as determined by 222. The thickness of the screw shaft coupling

flange is not to be less than 0,25 of the diameter required for the intermediate shaft as determined by 203 or H 303, whichever is applicable.

224 The fillet radii at the base of flanges should not be less than 0,125 of the diameter of the shaft.

225 Where couplings are separate from the shafts provision is to be made to resist the astern pull.

Bronze Propellers

226 Where bronze is used for propellers or propeller blades, it is to comply with the requirements of P 10.

Section 3

TURBINES AND PROPELLING MOTORS

Dimensions of Shafts

301 The intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 44-52 kg. per mm.^{2}, are to be of not less diameters than those given by the following formulæ.

Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Torsional Vibrations

302 The formulæ do not, however, take into consideration the possibility of torsional vibration arising in the shafting and gearing.

With turbines or electric motors geared to the shafting and situated aft, calculations of the torsional vibration characteristics for the dynamic system formed by the turbine, motor, gearing, line shafting and propeller are to be submitted for consideration, together with plans of all shafting and propeller and details of power developed by individual turbines throughout the speed range.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

Where serious critical speeds are found by calculation to occur within the range of working speeds the Committee may require torsiograph records to be taken from the machinery for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the vibration torques, as evidenced by tooth separation and gear hammer, are considered to be excessive.

Steam Reciprocating Engines combined with Exhaust Steam Turbines

303 Where steam reciprocating engines are combined with exhaust steam turbines by means of mechanical gearing the diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in millimetres}\end{array}\right\} d = 89\sqrt[3]{\frac{SHP}{R}}$$

where SHP = maximum combined shaft horse power at the intermediate shaft,

R = revolutions per minute at maximum power.

NOTE: The s.h.p. of a reciprocating engine may be taken as 90 per cent of the indicated horse power.

The diameter of the straight shafting should in no case be less than required for the reciprocating engine when working without a turbine.

The sizes of thrust, tube and screw shafts are to be determined by H 210 to H 213.

Turbines and Electric Propelling Motors

304 The diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in millimetres}\end{array}\right\} d = 89\sqrt[3]{\frac{SHP}{R}}$$

where SHP = maximum designed shaft horse power,

R = revolutions per minute at maximum power.

NOTE: The rule diameter of the intermediate shaft as determined by 303 or 304 may be reduced by 3,5 per cent for ships classed exclusively for smooth water service and by 1,75 per cent for ships classed exclusively for service on the Great Lakes.

Cross-references

305 For turbines and electric motors, the requirements for wheel, thrust, tube and screw shafts and associated items are to be in accordance with H 509, H 605 and H 614 to H 626.

Section 4

GENERAL REQUIREMENTS FOR STEAM RECIPROCATING ENGINES AND STEAM AND GAS TURBINES

Steam Reciprocating Engines

401 Explosion relief devices are to be fitted to the crank cases of enclosed forced lubricated steam reciprocating engines where the crank case volume is 0,57 m.^{3} and over. The arrangement and sizes of the relief devices are to comply with the requirements of H 713 to H 716 where applicable. There is also to be compliance with H 718.

402 Auxiliary steam engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on, but for any A.C. installation the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of $\pm$0,5 per cent.

Hydraulic Tests

403 The cylinders of steam reciprocating engines are to be tested by hydraulic pressure as follows:—

COMPOUND EXPANSION ENGINES:

H.P. Cylinder	WP $\times$ 1,5
L.P. Cylinder	2 kg. per cm.^{2}

TRIPLE EXPANSION ENGINES:

H.P. Cylinder	WP $\times$ 1,5
I.P. Cylinder	WP $\times$ 0,5
L.P. Cylinder	2 kg. per cm.^{2}

QUADRUPLE EXPANSION ENGINES:

H.P. Cylinder	WP $\times$ 1,5
First I.P. Cylinder ...	WP $\times$ 0,6
Second I.P. Cylinder ...	WP $\times$ 0,4
L.P. Cylinder	2 kg. per cm.^{2}

Where WP is the boiler working pressure in kg. per cm.^{2}

Astern Power

404 Ships are to have sufficient power for going astern to secure proper control of the ship in all normal circumstances.

Trials

405 The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions.

In the case of passenger ships, the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manœuvring conditions, and so bring the ship to rest from maximum ahead service speed is to be demonstrated at the sea trials.

All trials are to be to the Surveyor's satisfaction.

STEAM AND GAS TURBINES

General

406 The following requirements are applicable, except where otherwise stated, to steam and gas turbines for main propulsion and for essential auxiliary services where powers exceed 150 s.h.p. Features of gas turbine machinery which are not included in this section will be specially considered.

Plans

407 The following plans are to be submitted for consideration, together with particulars of materials and of maximum designed powers and speeds. The pressures and temperatures applicable at full power and under the emergency conditions of 443 are to be stated or indicated on the plans.

1. General arrangement.
2. Sectional assembly.
3. Rotors and couplings.
4. Cylinders.
5. Combustion chamber and heat exchangers.

For main steam turbines plans 1, 2 and 3 are required in all cases and 4 when the cylinders are of welded construction. In general for auxiliary steam turbines no plans need be submitted. For main and auxiliary gas turbines plans 1 to 5 are required.

Where rotors and cylinders are of welded construction plans showing details of the welded joints are also to be submitted for consideration.

Materials

408 Plates, forgings, castings and pipes used in the construction of turbine cylinders, rotors, couplings and other important components are to be of approved composition and be tested in accordance with the relevant requirements of Chapter P, or of an approved Specification.

409 In the selection of materials for high temperature applications in advanced steam and gas turbines consideraiton is to be given to their creep strength, corrosion resistance

and scaling properties at working temperatures to ensure satisfactory performance and long life under service conditions.

Stability Testing of Turbine Rotors

410 All solid forged H.P. steam and gas turbine rotors intended for main propulsion service where the inlet steam or gas temperature exceeds 750° F. (400° C.) are to be subjected to at least one thermal stability test. This requirement is also applicable to rotors fabricated as in 426. The test may be carried out at the Forge or Turbine Builders' Works (*a*) after heat treatment and rough machining of the forging, or (*b*) after final machining, or (*c*) after final machining and blading of the rotor. The stabilising test temperature is to be not less than 50° F. (28° C.) above the maximum steam or gas temperature to which the rotor will be exposed and not more than the tempering temperature of the rotor material. For details of a recommended test procedure and limits of acceptance *see* P 6. Other test procedures may be adopted if approved.

Where main turbine rotors are subjected to thermal stability tests at both Forge and Turbine Builders' Works the foregoing requirements are applicable to both tests. It is not required that auxiliary turbine rotors be tested for thermal stability, but if such tests are carried out, the requirements for main turbine rotors will be generally applicable.

Design and Construction

411 In the design and arrangement of turbine machinery adequate provision is to be made for the relative thermal expansion of the various turbine parts, and special attention is to be given to minimising casing and rotor distortion under all operating conditions.

412 Indicators for determining the axial position of rotors relative to their casings and for showing the longitudinal expansion of casings at the sliding feet, if fitted, are to be provided for main turbines. The latter indicators should be fitted at both sides and be readily visible.

413 Pipes and ducts connected to turbine casings are to be so designed that no excessive thrust loads or moments are applied by them to the turbines. Gratings and any fittings in way of sliding feet or flexible-plate supports are to be so arranged that casing expansion is not restricted. Where main turbine seatings incorporating a tank structure are proposed, consideration is to be given to the temperature variation of the tank in service to ensure that turbine alignment will not be adversely affected.

414 In arranging the gland-sealing system of steam turbines the pipes are to be made self-draining and every precaution is to be taken against the possibility of condensed steam entering the glands and turbines. The steam supply to the gland-sealing system is to be fitted with an effective drain trap. In the air ejector re-circulating water system the connection to the condenser is to be so located that water cannot impinge on the L.P. rotor or casing.

415 The turning gear for all propulsion turbines is to be power-driven and if electric is to be continuously rated.

416 Turbine rotors are to be made of forged material with a tensile strength for low alloy steel not exceeding 91 kg. per mm.^{2} for solid rotors and 107 kg. per mm.^{2} for the discs and spindles of built rotors. Where carbon steel forgings are adopted the tensile strength is not to exceed 71 kg. per mm.^{2} (*See* P 6.)

417 Discs of built rotors fitted by shrinking are to be secured with keys, dowels or other approved means in main turbines.

418 Smooth fillets are to be provided at abrupt changes of section of rotors, spindles, discs, blade roots and tenons. The rivet holes in blade shrouds are to be rounded and radiused on top and bottom surfaces and tenons to be radiused at junction with blade tips. Balancing holes in discs are to be well rounded and polished.

419 Surveyors are to be satisfied as to the workmanship and riveting of blades to shroud bands and that the blade tenons are free from cracks, particularly with high tensile blade material. Test samples are to be sectioned and examined and pull-off tests made if considered necessary by the Surveyors.

420 All rotors, as finished-bladed and complete with half coupling, are to be dynamically balanced in a machine of appropriate sensitivity for the size of rotor, to the Surveyors' satisfaction.

421 Turbine cylinder castings are to be of approved material suitable for the working metal temperature. Ordinary cast iron is not to be used for temperatures exceeding 500° F. (260° C.) The castings are to be stress relief heat treated after rough machining, except that this requirement may be waived for small castings at the Surveyors' discretion. The stress relieving temperature is not to exceed the tempering temperature. (*See* P 5 for Steel Castings.)

422 Turbine bearings are to be so disposed and supported that lubrication is not adversely affected by heat flow from adjacent hot parts of the turbine. Effective means

are to be provided for intercepting oil leakage and preventing any oil from reaching high temperature glands and casings. Drainage openings from oil baffles are to be amply large. (*See* H 104 for alignment gauges.)

Welded Components

423 Turbine rotors, cylinders and associated components fabricated by means of welding will be considered for acceptance if constructed by firms whose works are properly equipped to undertake welding of equivalent standards, for rotor and cylinders respectively, to those required by the Rules for Class 1 and 2 Welded Pressure Vessels. (*See* J 19 and J 20.)

424 Welded combustion chambers, heat exchangers, gas collector vessels, pressure ducting and piping are to comply with the relevant sections of Chapters J (pressure vessels) and E (pipes).

425 Materials used in the construction of turbine rotors, cylinders, diaphragms, condensers, etc., are to be of welding quality.

426 Where it is proposed to construct rotors from two or more forged components joined by welding, full details of the chemical composition, mechanical properties and heat treatment of the materials, together with electrode particulars, an outline of the welding procedure, method of fabrication and heat treatment are to be submitted for consideration.

427 Joints in rotors and major joints in cylinders are to be designed as full-strength welds and for complete fusion of the joint.

428 In the first instance and before work is commenced the Surveyors are to be satisfied that the desired quality of welding is attainable with the proposed welding procedure, and for this purpose test specimens representative of the welded joints are to be provided for radiographic examination and mechanical tests. For cylinders the mechanical tests of butt joints are to include tensile, bend and nicked bend tests as detailed in J 20. For diaphragms, nozzle plates etc., representative samples are to be sectioned and macro-etched. For rotors the mechanical tests are to include tensile (all weld metal), tensile (joint), bend (transverse), bend (longitudinal) and macro tests as detailed in J 19 or such other tests as may be approved. In subsequent production, check mechanical tests are to be carried out at the Surveyors' discretion if the quality of the welding is found to be unsatisfactory.

429 Adequate preheating is to be employed for mild steel cylinders and components where the metal thickness exceeds 44 mm. and for all low alloy steel cylinders and components and for any part where necessitated by joint restraint.

430 Stress relief heat treatment is to be applied to all cylinders and associated components on completion of the welding of all joints and attached structures. (*See* J 1925 for details of stress relief procedure, temperature and duration.)

431 The heat treatment of welded rotors is to be carried out as approved.

432 Routine examinations by non-destructive methods are to be made of all cylinders and rotors on completion of heat treatment as follows:—

CYLINDERS.—Major stressed joints in pressure shells are to be radiographed if practicable; other joints such as nozzle plate and branch pipe connections and diaphragm joints are to be examined by crack detection methods.

ROTORS.—All joints are to be examined by radiography or other approved methods and by magnetic crack detection methods.

433 The whole of the welding work is to be to the satisfaction of the Surveyors.

Governors and other Safety Devices

434 An emergency overspeed governor is to be provided for main and auxiliary steam turbines so as to shut off the steam automatically and prevent the maximum designed speed being exceeded by more than 15 per cent.

435 Where two or more propulsion turbines are coupled to the same main gear wheel and only one emergency governor is provided, it is to be fitted to the L.P. ahead turbine. Hand trip gear for shutting off the steam in emergency is to be provided at the manœuvring platform.

436 Arrangements are to be made for the steam to the ahead propulsion turbines to be automatically shut off in the event of failure of the lubricating oil pressure. (*See* E 904 for emergency oil supply).

437 Where a turbine installation incorporates a reverse gear, electric transmission or reversible propeller, a speed governor in addition to, or in combination with, the

emergency governor is to be fitted and is to be capable of controlling the speed of the unloaded turbine without bringing the emergency governor into action.

438 Auxiliary turbines intended for driving electric generators are to be fitted with speed governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on, but for any A.C. installation the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of $\pm$ 0,5 per cent.

439 Sentinel relief valves are to be provided at the exhaust ends or other approved positions of all main steam turbines and the valve discharge outlets are to be visible and suitably guarded if necessary. Where a low vacuum cut-out valve is provided the sentinel relief valve at the L.P. exhaust may be omitted.

440 Non-return valves or other means, which will prevent steam and water returning to the turbines, are to be fitted in bled steam connections.

441 Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines, or alternatively at the inlets to the manœuvring valves.

442 The governing and other safety devices for propulsion gas turbine installations will be specially considered.

Emergency Arrangements

443 In single screw ships fitted with steam turbines the arrangements are to be such that steam can be led direct to the L.P. turbine and either the H.P. or I.P. turbine can exhaust direct to the condenser. Adequate arrangements and controls are to be provided for these emergency conditions so that the pressure and temperature of the steam will not exceed those which the turbines and condenser can safely withstand.

Astern Power

444 Sufficient astern power is to be provided to maintain control of the ship in all normal circumstances and in general for this purpose the astern turbine or turbines of steam and free-piston gas turbine installations are to be designed to develop when operating astern under transient conditions 80 per cent of the ahead torque at 50 per cent of the ahead revolutions and to maintain in free route astern 70 per cent of the ahead revolutions for a period of at least 30 minutes without undue heating of the ahead turbines and condenser. The aforementioned ahead torques and revolutions are to be based on the maximum ahead power for which the machinery is to be classed.

Hydraulic Tests

445 Manœuvring valves are to be tested to twice the working pressure. The nozzle boxes of impulse turbines are to be tested to 1,5 times the working pressure.

The cylinders of all turbines are to be tested to 1,5 times the working pressure in the casing or to 2 kg. per cm.^{2}, whichever is the greater.

For test purposes the cylinders may be sub-divided with temporary diaphragms for distribution of test pressures.

Condensers are to be tested in the steam space to 1 kg. per cm.^{2}. The water space is to be tested to the maximum pressure which the pump can develop with the discharge valve closed plus 0,7 kg. per cm.^{2}, with a minimum test pressure of 2 kg. per cm.^{2}. Where the operating conditions are not known, the test pressure is to be not less than 3,5 kg. per cm.^{2}. *See* E 802.

Trials

446 The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions. Where astern turbines or hydraulic reversing gear are fitted, astern running at 70 per cent of the full power ahead revolutions is to be demonstrated. The astern trial need only be of 15 minutes duration, but may be extended to 30 minutes at the Surveyors' discretion.

In the case of passenger ships, the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manœuvring conditions, and so bring the ship to rest from maximum ahead service speed is to be demonstrated at the sea trials.

All trials are to be to the Surveyor's satisfaction.

Cross-references

447 Turbines intended for driving electric generators are to comply with the requirements of M 401 and M 402.

448 Where auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares are to comply with the requirements of Chapter M.

449 The feed, bilge and general service pumps, steam and other pipes, cocks, sea connections, pumping arrangements and forced lubrication, are to comply with the requirements of Chapter E.

Section 5

REDUCTION GEARING FOR PROPELLING AND AUXILIARY MACHINERY

General

501 The following requirements, except where otherwise stated, are applicable to reduction gearing for main propelling purposes and for driving electric generators where the transmitted powers exceed 300 s.h.p. and 150 s.h.p. for propulsion and auxiliary drives respectively. In any mesh, the terms pinion and wheel refer to the smaller and larger gear respectively. Epicyclic and bevel gears will be specially considered.

502 The materials for pinions, pinion sleeves, wheel rims, flexible couplings and quill shafts are to be of approved composition and mechanical properties and are to comply with the requirements of Chapter P. Manufacturer's certificates of test for materials may be accepted in cases where the transmitted power of gears is less than 150 s.h.p.

In the selection of materials for pinions and wheels consideration is to be given to their compatibility in operation. In general, for gears of through-hardened steels, except in the case of low reduction ratios, provision is also to be made for a hardness differential between pinion teeth and wheel teeth for which purposes the specified minimum tensile strength of the wheel rim material is to be not more than 85 per cent of that of the pinion.

503 Particulars of the gearing are to be submitted with the plans for all propulsion gears and for auxiliary gears where the transmitted power exceeds 150 s.h.p., as follows:—

Material specifications,
Shaft horse power and revolutions for each pinion,
Number of teeth in each gear,
Pitch circle diameters,
Helix angles,
Normal pitches of teeth,
Addenda,
Dedenda,
Face widths,
Pressure angles of teeth (normal or transverse),
Minimum backlash,
Centre distance.

Design

Tooth Form

504 The tooth profile in the transverse section is to be of involute shape and the roots of the teeth are to be formed with smooth fillets of radii, not less than 12 per cent of the normal pitch.

For propulsion gears the ends of the pinion and wheel teeth are to be cut back from the root at an angle of 45° to 60° to the pitch line in all cases where the ratio F/d exceeds 1,5.

where F = total axial length over pinion helices, less the gap, in mm.,

d = pitch circle diameter of pinion, in mm.

The teeth of pinions and wheels of turbine gears are to be suitably tip-relieved in cases where any of the following conditions apply:—

(i) Normal pitch of teeth exceeds 20 mm.

(ii) Addendum of pinion teeth exceeds 65 per cent of total working depth of engagement.

(iii) Ratio of total working depth of engagement to normal pitch of teeth exceeds 0,75.

All sharp edges left on the tips and ends of pinion and wheel teeth after hobbing or finishing are to be removed.

Deflection of Pinions

505 In order to limit tooth opening arising from loaded deflections, the total axial length, in mm., over the gear face, less gap where applicable, is not to exceed

$$c \times d$$

where d = pitch circle diameter of pinion, in mm.

c = factor to be determined as follows:—

A = helical angle in degrees.

(a) double-helical pinion meshing with one wheel

$$c = \frac{105 + A}{60}$$

(b) double-helical pinion meshing with two wheels diametrically opposed

$$c = \frac{80 + A}{40}$$

(c) single-helical pinion meshing with one or two wheels

$$c = \frac{75 + A}{60}$$

For spur gears the face width/diameter ratio is not to exceed 1,25.

Alternatively, manufacturers may present deflection calculations with details of any intended measures to improve load distribution.

506 In order to limit the tooth surface stress, the tooth load for the maximum designed shaft horse power is not to exceed that given by the following formula:—

$$W = K \times d \times \frac{G}{(G + 1)}$$

where W = maximum permissible tangential tooth load, in kg. per cm., of overall face width, less gap where applicable.

K = loading factor derived as follows:—

(a) For Turbine Gearing

$$K = \left[\frac{5850 + (d \times N)}{1600000}\right] \times S \times B$$

(b) For Oil Engine Gearing

$$K = \left[\frac{2300 - (d \times N)}{170000}\right] \times S \times B$$

where d = pitch circle diameter of pinion, in mm.,

N = revolutions per minute of pinion, divided by 1000,

S = value according to Table 1,

S_1 = specified minimum tensile strength of pinion material, in kg. per mm.^{2},

S_2 = specified minimum tensile strength of wheel material, in kg. per mm.^{2},

F = total axial length over the gear face, less gap, in mm.,

H = F for single helical and spur gears, or $F/2$ for double helical gears,

p_a = axial pitch of teeth, in mm.,

G = gear ratio:— $\frac{\text{pinion speed}}{\text{wheel speed}}$

B = 1, if $H \geqslant 1{,}15\ p_a$,

= 0,6, if $H < 1{,}15\ p_a$.

For divided power transmission where a pinion meshes with two or more wheels or a wheel meshes with two or more pinions, the value of S determined for that gear is to be reduced by 12 per cent.

The permissible loading may be increased by 10 per cent in single reduction gearing for main propelling purposes and in double reduction gearing where it is proposed to connect the primary and secondary gears of single helical gears or spurs, by means of a quill shaft, or approved equivalent, also for double helical gears where, in addition to a quill shaft, provision is made for either:—

(i) a coupling providing axial articulation, or

(ii) (a) both helices of the main wheel are finish hobbed in the same direction of rotation and at the same setting of the blank on the hobber table;

or alternatively,

(b) the matching of the cumulative pitch errors on the two helices can be shown to be within acceptable limits.

Where single reduction gearing is used for auxiliary drives, the permissible loading may be increased by 15 per cent.

Where the teeth of gears made of through-hardened steels are finished by an approved post-hobbing process, or profile ground, or where it can be demonstrated in advance that the finish and profile of the teeth are equivalent, the permissible loading, resulting from the product of any allowance factors, may be increased by up to 25 per cent.

Tooth Strength

507 In order to limit the bending stress at the root section of gear teeth, the fillet radius should be blended smoothly into the involute profile and the normal pitch of the teeth should be not less than that given by the following formula:—

$$p_n = \frac{JCW_1}{(110-A)\ U}$$

where p_n = normal pitch of the teeth, in mm.,

W_1 = maximum proposed tangential tooth load, in kg. per cm., of overall face width, less gap where applicable.

F = total axial length over the gear face, less gap, in mm.,

H = F for single helical and spur gears or $F/2$ for double helical gears,

p_a = axial pitch of the teeth, in mm.,

J = 1, if $H \geqslant p_a$,

= $0{,}4\ (3{,}5 - H/p_a)$ if $H < p_a$,

$C = \frac{1700 + N}{1200}$, if $N \leqslant 1000$,

$= \frac{18000 + N}{8400}$, if $N > 1000$

A = helical angle, in degrees.

TABLE 1

HEAT TREATMENT AND SURFACE CONDITIONS		S	
PINION	WHEEL	TURBINE GEARING	OIL ENGINE GEARING
Through-Hardened	Through-Hardened	Lower value of $S_1 + 63$ or $\left(\frac{9+G}{10}\right)S_2+63$	Lower value of $S_1 - 8$ or $\left(\frac{9+G}{10}\right)S_2 - 8$
Carburised, Hardened and Ground Nitrided after post-hobbing by an approved process or Nitrided and Ground	Through-Hardened	345 (provided $S_2 \geqslant 63$)	$\left(\frac{9+G}{10}\right)S_2 - 8$
Carburised, Hardened and Ground Nitrided after post-hobbing by an approved process or Nitrided and Ground	Induction-Hardened and Ground	470	300
Nitrided after post-hobbing by an approved process or Nitrided and Ground	Nitrided after post-hobbing by an approved process or Nitrided and Ground	535	345
Carburised, Hardened and Ground	Carburised, Hardened and Ground	570	380

For nitrided and ground pinions or wheels the case thickness after grinding should not be less than 0,508 mm.

For the pinion or wheel under consideration:—

N = revolutions per minute,

UTS = specified minimum tensile strength (of core material for surface-hardened steels), in kg. per mm.^{2},

$U = \frac{UTS + 95}{450}$ if gear is through-hardened,

= 0,56 if gear is induction-hardened and ground, or nitrided after post-hobbing by an approved process,

= 0,60 if gear is nitrided and ground,

= 0,67 if gear is carburised, hardened and ground.

For an idler gear, C should be increased by 60 per cent.

Where the teeth of gears made of through-hardened steels are finished by an approved post-hobbing process, or profile ground, or where it can be demonstrated in advance that the finish and profile of the teeth are equivalent, U may be increased by up to 25 per cent for a specified minimum ultimate tensile strength not exceeding 88 kg. per mm.^{2}. For higher specified tensile strengths, U may be taken as 0,49.

The core tensile strength for surface-hardened steels must be not less than 79 kg. per mm.^{2}.

Alternative proposals to the foregoing together with calculations may be submitted for special consideration.

Quill Shafts

508 The diameter of the quill shaft is to be not less than given by the following formula:—

diameter of quill shaft, in mm. $= 90 \sqrt[3]{\frac{S\,HP}{R} \times \frac{44}{S}}$

where SHP = maximum designed power,

R = revolutions per minute at maximum designed power,

S = specified minimum tensile strength of the material in kg. per mm.^{2}, which is to be not less than 44 kg. per mm.^{2}.

509 Where there is only one pinion geared into the final wheel, or where there are two pinions which are set to subtend an angle at the centre of the shaft of less than 120 degrees, the diameter of the shaft at the final wheel and the adjacent journals is to be not less than 1,16 times that required for the intermediate shaft. Abaft the journals the shaft may be gradually tapered down to the diameter required for an intermediate shaft calculated according to H 304 or H 611, as applicable.

Where there are two pinions geared into the final wheel opposite, or nearly opposite to one another, the diameter of the final wheel shaft is to be not less than 1,1 times that required for an intermediate shaft calculated according to H 304 or H 611, as applicable.

Construction

Gear Wheels and Pinions

510 Where wheels are of cast construction any radial slots in the periphery are to be fitted with permanent chocks before shrinking of the rim.

When bolts are used to secure side plates to rim and hub, the bolts are to be a tight fit in the holes and not to be locked by welding.

When welding is employed in the construction of wheels, the welding procedure is to be approved in the first instance by the Surveyors before work is commenced. For this purpose, test specimens representative of the welded joints used in the construction of the wheel are to be provided for examination and mechanical test. Sections are also to be taken from the test joints at positions selected by the Surveyors, and are to be macro-etched to verify that the welds are sound. Wheels are to be stress relieved after welding. All welds are to have a smooth surface and even contour and are to be proved by magnetic crack detection methods.

In general, arrangements are to be made so that the interior structure of the wheel may be examined. Alternative proposals will be specially considered.

Gear Cases

511 Gear cases are to be of rigid design and if welding is employed in their construction they are to be stress relieved on completion. Provision is to be made by the gear manufacturers for verifying by trammels or other means during installation of the gear case on board ship that it is free from distortion when chocked and secured to its seating.

Inspection openings are to be provided at the peripheries of gear cases to enable the teeth of pinions and wheels to be readily examined. Where the construction of gear cases is such that sections of the structure cannot readily be moved for inspection purposes, access openings of adequate size are also to be provided at the ends of the gear cases to permit examination of the structure of the wheels. Their attachment to the shafts is to be capable of being examined by removal of bearing caps or by equivalent means.

Balance of Gear Pinions and Wheels

512 All pinions, gear wheels and flexible coupling sleeves whose maximum designed speed of rotation exceeds 1000 revolutions per minute are to be dynamically balanced. Where the speed of rotation is 1000 revolutions per minute or less, these components are to be statically or, alternatively, dynamically balanced.

Parts of couplings, etc., which are to be fixed to the gear in service shall normally be attached before balancing.

Accuracy of Gear Cutting and Alignment

513 Turbine gearing is to be cut only on machines which are maintained at a high standard of accuracy. When large gears are designed with loading factors exceeding K = 0,56, any hobbing machines used in their production are to operate under conditions of temperature control.

The accuracy of gear-cutting and alignment of pinions and wheels is to be demonstrated in the workshop to the satisfaction of the Surveyors.

Trials

514 Prior to full power sea trials, the teeth of pinions and wheels are to be thinly coated with copper sulphate, an approved spirit lacquer, or other equivalent. After these trials, the marking revealed by inspection is to indicate freedom from hard bearing and not less than 70 per cent contact across the effective face width with satisfactory contact over the involute profile. Where the teeth of gears

made of through-hardened steels are finished by an approved post-hobbing process, or profile ground, or where it can be demonstrated in advance that the finish and profile of the teeth are equivalent, and the increase in loading permitted by 506 and 507 is required, not less than 90 per cent contact across the effective face width should be indicated.

The sea trials are to be of sufficient duration to prove the gears. On conclusion, all gears are to be opened up sufficiently to permit the Surveyors to make an inspection of the teeth.

Cross-Reference

515 For lubricating oil systems, *see* E 9.

Section 6

OIL ENGINES

Dimensions of Shafts

601 The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 44–52 kg. per mm.^{2} are to be of not less diameters than those given by the following formulæ.

Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Torsional Vibrations

602 The formulæ do not, however, take into consideration the possibility of dangerous torsional vibration stresses arising in the shafting.

Calculations of torsional vibration characteristics for the dynamic system formed by the engine, shafting and propeller, also gearing, generators or other components, where these are interposed, are to be submitted for consideration, together with plans of all shafting and of the propeller. These calculations should include:—

(*a*) Natural frequency tables for one and two noded modes of vibration, also higher modes if necessary.

(*b*) Vector summation for all orders of vibration occurring at speeds up to 20 per cent above the service speed.

(*c*) Particulars of the firing order in the case of four-cycle engines.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

Where the Engine Builders' estimate of vibration stresses is based on torsiograph records from previous installations, particulars of the estimated stresses are to be submitted in cases where the stresses approach the limits indicated in the Society's Guidance Notes.

The torsional vibration characteristics of oil engines driving auxiliary machinery used for essential services at sea are to be such as to ensure that the operating speed ranges are clear of significant critical speeds. Where the power developed by these auxiliary engines is 150 b.h.p. or 100 kW and over, torsional vibration calculations are to be submitted for approval as required for propelling machinery.

Where serious critical speeds are found by calculation to occur within the range of working speeds the Committee may require torsiograph records to be taken from the machinery for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the stresses are considered to be excessive.

The submission of torsional vibration characteristics will not be required for ships classed for smooth water service when fitted with engines having powers less than 100 b.h.p.

See Chapter R(E) for Guidance Notes on Torsional Vibration Stresses and Critical Speeds for Main and Auxiliary Oil Engines.

Crank Shaft

603 The diameter of the crank shaft is not to be less than that given by the following formula:—

Diameter of crank shaft, in millimetres =

$$\sqrt[3]{\frac{D^2 \times (PL + CpS) \times 14{,}22}{10000}}$$

where D = diameter of cylinder, in millimetres,

S = length of stroke, in millimetres,

L = span of bearings adjacent to a crank measured from inner edge to inner edge, in millimetres,

P = maximum pressure in kg. per cm.^{2},

p = mean indicated pressure in kg. per cm.^{2},

C is a coefficient found from Table 2.

TABLE 2. FOR CRANK SHAFTS

Maximum Pressure 35 kg. per cm.^{2} and above

Single Acting Engines		
Number of Cylinders		C
4 Stroke Cycle	2 Stroke Cycle	
1, 2, 3 or 4	1 or 2	7,3
5 or 6	3	7,7
7 or 8	4	8,6
9 or 10	5	9,3
11 or 12	6	9,6
—	7	9,8
—	8	10,0
—	9	11,2
—	10	12,3
—	11	12,7
—	12	13,5

Crankshafts for Vee-Engines

604 The diameter of the crankshaft is not to be less than that given by the following formula:—

$$\text{Diameter of crankshaft, in mm.} = \sqrt{\frac{D^2 \times (APL + BCpS) \times 14,22}{10000}}$$

where D = diameter of cylinder, in mm.,

S = length of stroke, in mm.,

L = span of bearings adjacent to crank measured from inner edge to inner edge, in mm.,

P = maximum pressure in kg. per cm.^{2},

p = mean indicated pressure in kg. per cm.^{2},

$A = \frac{100 - \theta}{110}$ but not to be taken as less than 0,4,

$B = 4,5 + P/p$

θ = proposed minimum firing interval between two cylinders on one crankpin, in degrees,

C = coefficient from Tables 3 or 4 for 2 stroke and 4 stroke single acting engines respectively.

Engines not covered by values of C given in Tables 3 or 4 will receive special consideration.

As an alternative to the above method, detailed calculations may be submitted for special consideration.

TABLE 3, for 2SCSA Engines

NUMBER OF CYLINDERS	θ (DEGREES)				
	36	45	50	63,5	90
4	—	—	—	—	1,02
6	—	1,09	—	1,24	1,18
8	1,42	1,23	—	1,39	1,92
10	1,37	—	—	—	—
12	1,65	1,85	2,03	1,61	1,50
14	1,69	—	—	—	—
16	2,13	2,16	2,07	—	—

605 Where it is proposed to make solid forged crank shafts of steel having a specified minimum tensile strength greater than 44 kg. per mm.^{2}, but not exceeding 80 kg. per mm.^{2}, the diameter of the crank shaft is not to be less than given by the following formula:—

$$\text{Diameter of crank shaft in millimetres} = d \times \sqrt[3]{\frac{44}{0,72T + 12,6}}$$

where d = diameter, in millimetres, of crank shaft made of steel having a specified minimum tensile strength of 44 kg. per mm.^{2} as required by 603 or 604 as applicable.

T = proposed specified minimum tensile strength in kg. per mm.^{2}

This formula may be applied to built and semi-built crank shafts and to thrust and intermediate shafts, but where it is proposed to use high tensile material for these applications, full particulars are to be submitted for consideration.

Crank Webs of Solid Forged Shafts

606 The dimensions of crank webs are to be such that the Bt^2 is not less than $0,4d^3$.

TABLE 4, for 4SCSA Engines

NUMBER OF CYLINDERS	θ (DEGREES)											
	40	45	50	60	80	90	270	280	300	310	315	320
4	—	—	—	—	—	1,06	1,06	—	—	—	—	—
6	—	1,27	—	1,23	—	1,06	1,39	—	1,33	—	1,25	—
8	—	1,50	—	1,17	—	1,16	—	—	1,04	—	0,95	—
10	—	1,41	—	—	—	—	—	—	—	—	1,57	—
12	1,31	1,36	1,26	1,23	1,25	1,14	1,39	1,32	1,33	1,27	1,28	1,25
14	—	1,36	—	—	1,55	—	—	1,48	—	—	1,96	—
16	—	1,45	1,42	1,45	1,83	2,04	2,01	1,91	1,41	1,39	1,35	—
18	1,36	1,51	—	—	1,94	1,78	1,54	1,57	—	—	2,12	2,02
20	—	—	1,55	—	—	—	—	—	—	1,48	—	—

Where B = breadth of web, in millimetres,

t = axial thickness of web, which is not to be less than $0{,}45d$, in millimetres,

d = diameter of crank shaft, in millimetres, as required by 603, 604 or 605 as applicable.

Where the journals and pins overlap, allowance for the diagonal section between the journals and pins may be made in determining the Bt^2.

Crank Webs of Built and Semi-Built Shafts

607 The dimensions of the crank webs of built and semi-built shafts should not be less than those given by the following formulæ:—

$$h = 0{,}625 \times d$$

$$t = \sqrt{\frac{0{,}12 \times d^3}{h}}$$

where h = thickness of the web, measured parallel to the axis, in millimetres,

t = thickness of metal around the holes measured radially, in millimetres,

d = diameter of crank shaft, in millimetres, as required by 603 or 604 as applicable.

If these proportions are departed from, the webs are to be of equivalent strength, but in no case is the axial thickness h to be less than $0{,}525d$.

608 Reference marks are to be provided on the outer junction of the crank webs with the journals and crank pins.

Shrinkage Allowance

609 Crank webs are to be securely shrunk on the journals and crank pins and the yield point of the material of the webs is to be not less than 22 kg. per mm.^{2}.

For solid journals and pins, the shrinkage allowance is to be between $\frac{1}{550}$ and $\frac{1}{700}$ of the diameter of these parts.

Where the journals and pins are hollow-bored, the diameter of the central hole is not to exceed one half of the diameter of the journal or pin and the shrinkage allowance is to be between those obtained by the following formulæ:—

$$\frac{1}{\left[550-400\left(\frac{H}{D}\right)^2\right]} \quad \text{and} \quad \frac{1}{\left[700-500\left(\frac{H}{D}\right)^2\right]}$$

where H = diameter of hole in journal or pin, in millimetres,

D = diameter of hole in crank web, in millimetres.

Fillets and Oil Holes

610 Fillets at the junctions of crank webs with crank pins or journals, where these are formed as solid forgings or castings, are to be machined to a radius of not less than 5 per cent of the diameter of the crank shaft and are to have a smooth finish.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

Intermediate Shaft

611 The diameter of the intermediate shaft d is to be determined by formula (1) or, where the necessary particulars are available, by formula. (2)

$$d, \text{ in millimetres} = 25{,}4 \times C \sqrt[3]{\frac{BHP}{R}} \quad \text{.....(1)}$$

$$d, \text{ in millimetres} = 89 \sqrt[3]{\frac{BHP}{R}\left(\frac{X+A}{1+A}\right)} \quad \text{.....(2)}$$

Where BHP = maximum designed brake horse power,

R = revolutions per minute of the intermediate shaft at maximum power,

C = coefficient obtained from Table 5,

X = ratio of maximum to mean indicated torque at the after cylinder,

$$A = \frac{Je}{Jp}$$

Je = total mass moment of inertia of engine, including reciprocating and revolving parts and flywheel, also gearing if fitted,

Jp = mass moment of inertia of propeller including entrained water referred to crank shaft speed.

NOTE 1.—Formula (1) is applicable only to single piston in-line engines with approximately equal firing intervals.

NOTE 2.—Formula (2) is applicable to all engines without restriction of any kind and may allow, in some cases, a smaller shaft diameter than formula (1).

NOTE 3.—Where a percentage figure for the mass of water entrained by the propeller is not available, it may be taken as 25 per cent.

TABLE 5

4 STROKE SINGLE ACTING		2 STROKE SINGLE ACTING	
Number of Cylinders	C	Number of Cylinders	C
1 to 4	4,30	1 or 2	4,50
5	4,15	3	4,20
6	4,05	4	4,00
7	4,00	5	3,90
8	3,90	6	3,80
9	3,85	7	3,75
10	3,70	8	3,65
11 and over	3,55	9 & over	3,55

NOTE.—The Rule diameter of the intermediate shaft may be reduced by 3,5 per cent for ships classed exclusively for smooth water service and by 1,75 per cent for ships classed exclusively for service on the Great Lakes.

Flywheel Shaft

612 The diameter of the flywheel shaft is to be not less than that required for the crank shaft. Shafts carrying light turning wheels are excepted from this requirement.

Cross-reference

613 For wheel shafts for geared oil engines, *see* H 509.

Thrust Shaft

614 The diameter at the collars of the thrust shaft transmitting torque is to be not less than 1,15 times that required for the intermediate shaft; outside the collars the diameter may be tapered down to that required for the intermediate shaft.

Tube Shaft

615 The diameter of the tube shaft (i.e. the shaft which passes through the stern tube, but does not carry the propeller) is not to be less than 1,14 times that required for the intermediate shaft, and any part of the shaft within or without the tube which may be exposed to sea water is not to be less than 1,17 times that required for the intermediate shaft.

Screw Shaft

616 The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in millimetres} = 1{,}14d + \frac{P}{C}$$

where d = diameter required for the intermediate shaft, in millimetres,

P = diameter of the propeller, in millimetres,

C = 144 when the shaft is fitted with a continuous liner or is oil lubricated and provided with an approved type of oil sealing gland,
100 for other shafts.

Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1,14 times that required for the intermediate shaft. Abrupt changes in shaft section at the screw shaft to intermediate shaft couplings should be avoided.

617 The propeller boss is to be a good fit on the screw shaft cone. The length of the forward fitting surface should be about one diameter. The forward edge of the bore of the propeller boss is to be rounded to about a 6 mm. radius.

Propeller Keys and Keyways

618 Round ended or sled-runner ended type keys are to be used and the keyways in the propeller boss and cone of the screw shaft are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0,0125 of the diameter of the screw shaft at the top of the cone. The sharp edges at the top of the keyway are to be removed.

Two screwed pins should be provided for securing the key in the keyway and the forward pin should be placed at least one third of the length of the key from the end. The depth of the tapped holes for the screwed pins should not exceed the pin diameter, and the edges of the holes should be slightly bevelled.

The distance between the top of the cone and the forward end of the keyway is to be not less than 0,2 of the diameter of the screw shaft at the top of the cone.

The effective sectional area of the key in shear, in square millimetres, is to be not less than $\frac{d^3}{2{,}5d_1}$

where d = diameter required for the intermediate shaft, in millimetres,

d_1 = diameter of shaft at mid-length of the key, in millimetres.

Hollow Shafts

619 Where the thrust, intermediate, tube and screw shafts have central holes, the dimensions of the shafts as determined by the foregoing formulæ need not be increased, provided the diameter of the central hole in a shaft does not exceed one-third of the shaft diameter.

Bronze or Gunmetal Liners on Shafts

620 The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less, when new, than that given by the following formula:—

$$t \text{ in millimetres} = \frac{D + 230}{32}$$

where t = thickness of the liner, in millimetres,

D = diameter required for the screw or tube shaft under the liner, in millimetres.

The thickness of a continuous liner between the bushes is not to be less than 0,75 t.

621 Continuous liners should preferably be cast in one piece.

Where, however, liners consist of two or more lengths, these are to be butt welded together. In general, the lead content of the gunmetal of each length forming a butt welded liner is not to exceed 0,5 per cent. The composition of the electrodes or filler rods is to be substantially lead-free.

The circumferential butt welds are to be of multi-run, full penetration type. Provision is to be made for contraction of the weld by arranging for a suitable length of the liner containing the weld, if possible about three times the shaft diameter, to be free of the shaft. To prevent damage to the surface of the shaft during welding, a strip of asbestos or other heat resisting material covered by a copper strip should be inserted between the shaft and liner in way of the joint. Other methods for welding this joint may be accepted if approved. The welding is to be carried out by an approved method and to the Surveyors' satisfaction.

Each continuous liner or length of liner is to be tested by hydraulic pressure to 2 kg. per cm.^{2} after rough machining.

Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

622 Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

Stern Bush

623 The length of the bearing in the stern bush next to and supporting the propeller is to be as follows:—

(*a*) For water-lubricated bearings which are lined with lignum vitae, rubber composition or approved plastic material, the length is to be not less than four times the diameter for the screw shaft under the liner.

Forced water lubrication is to be provided for all bearings lined with rubber or plastic and for those bearings lined with lignum vitae where the shaft diameter is 380 mm. or over. The supply of water may come from a circulating pump or other pressure source. Flow indicators are to be provided for the water service to plastic and rubber bearings. The water grooves in the bearings should be of ample section and of a shape which will be little affected by weardown, particularly for bearings of the plastic type.

The shut-off cock or valve controlling the supply of water is to be fitted direct to the after peak bulkhead or to the stern tube where the water supply enters the stern tube forward of the bulkhead.

(*b*) For bearings which are white metal lined, oil lubricated and provided with an approved type of oil sealing gland, the length of the bearing is to be such that the nominal bearing pressure resulting from the weight of propeller and shaft will not exceed 5 kg. per cm.^{2}. In no case is the length of the bearing to be less than $2\frac{1}{2}$ times the diameter required for the screw shaft. The weight of the propeller and of screw shaft, and the type of oil sealing gland are to be stated when the plans are submitted for approval.

(*c*) For bearings of cast iron and bronze which are oil lubricated and fitted with an approved oil gland, the length of the bearing is, in general, to be not less than 4 times the diameter required for the screw shaft.

(*d*) For bearings which are grease lubricated the length of the bearing is to be not less than 4 times the diameter required for the screw shaft.

Oil sealing glands fitted in ships classed for unrestricted service must be capable of accommodating the effects of differential expansion between hull and line of shafting in sea temperatures ranging from Arctic to Tropical. This requirement applies particularly to those glands which span the gap and maintain oil tightness between the sterntube and the propeller boss.

Where a tank supplying lubricating oil to the stern bush is fitted it is to be located above the load water line and is to be provided with a low level alarm device in the engine room.

Where stern bush bearings are oil lubricated, provision should be made for cooling the oil by maintaining water in the after peak tank above the level of the stern tube or by other approved means. Means for ascertaining the temperature of the oil in the stern tube should also be provided.

NOTE.—Where there is compliance with the terms of (*b*) and (*c*) to the Surveyors' satisfaction a screw shaft will be assigned the notation O.G. in the supplement to the Register Book for periodical survey purposes (*see* C 1101).

Screw shafts which are grease lubricated are not eligible for the O.G. notation.

Coupling Bolts

624 With coupling bolts of ordinary mild steel having a minimum tensile strength of 44 kg. per mm.^{2}, the diameter of the bolts at the joining faces of the couplings is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of coupling bolts, in millimetres,}\end{array}\right\} = C\sqrt{\frac{d^3}{n \times r}}$$

Where n = number of bolts in the coupling,

r = radius of pitch circle of bolts, in millimetres.

For coupling bolts for thrust, intermediate, tube and screw shafts,

$C = 0{,}6$,

d = diameter required for intermediate shaft, in millimetres.

For coupling bolts for crank shafts,

$C = 0{,}5$,

d = diameter required for the crank shaft, in millimetres.

Where the specified minimum tensile strength of the crank shaft is greater than 44 kg. per mm.^{2}, and the diameter of the shaft is determined by 605, the coupling bolts for this shaft are to be of equivalent strength.

Coupling Flanges

625 The thicknesses of the coupling flanges at the pitch circle of the bolt holes are not to be less than the diameters of the coupling bolts at the face of the couplings as required by 624. In the case of the thrust shaft/crank shaft coupling the dimensions of the coupling bolts and flange thickness are to be governed by the crank shaft requirements. The thickness of the screw shaft coupling flange is not to be less than 0,27 of the diameter required for the intermediate shaft, as determined by 611.

The fillet radius at the base of the coupling flange is to be not less than 0,08 of the diameter of the shaft at the coupling, but in the case of crank shafts, the fillet radius at the centre coupling flanges may be 0,05 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and should not be recessed in way of nuts and bolt heads.

Where a coupling is shrunk on the parallel portion of a shaft or is mounted on a slight taper by means of the oil pressure injection method, the interference fit is to be in general accordance with the requirements of 609.

Where couplings are separate from the shafts, provision is to be made to resist the astern pull.

All couplings which are attached to shafts are to be of approved dimensions.

See paragraph 108, Chapter R(E)—Guidance Notes on Torsional Vibration Stresses.

Propellers

626 Where bronze or cast steel is used for propellers or propeller blades, the materials should comply with the relevant requirements of Chapter P, or an approved specification.

Cast iron propellers are to be made of a high duty iron of at least 27 kg. per mm.^{2} tensile strength, or of a nodular or spheroidal graphite ductile type cast iron.

CAST IRON CRANK SHAFTS

General

627 Where it is proposed to make crank shafts of cast iron, the material specification and the dimensions of the shaft are to be submitted for special consideration.

Material

628 The material specification should state the type of cast iron, the heat treatment, and mechanical properties, including the specified minimum tensile strength appropriate to the section of the crank shaft casting.

629 Any suitable type of high duty cast iron may be used, provided the minimum specified tensile strength is between 32 and 76 kg. per mm.^{2} Crank shafts are to be cast at a foundry approved for the production of cast iron crank shafts. (*See* P 19).

Crank Shafts

630 The diameter of the crank shaft is not to be less than that given by the following formula:—

$$\text{Diameter of crank shaft, in millimetres,} = d \times \sqrt[3]{\frac{22}{0{,}3T + 7{,}9 - \frac{d}{48}}}$$

where d = diameter, in millimetres, required by 603 or 604 as applicable for a steel crank shaft having a tensile strength of 44 kg. per mm.^{2}

T = specified minimum tensile strength of cast iron, in kg. per mm.^{2}, which is not to be less than 32 kg. per mm.^{2}

631 Special consideration will be given to crank shafts which have been designed and developed for optimum fatigue strength with cranks of the most favourable shape, and some allowance made for the superior strength thereby obtained. Particulars of any relevant tests or experience should be submitted.

Crank Webs

632 The breadth of the webs should not be less than 1,33 times and the thickness not less than 0,56 times the diameter of the shaft required by 630. If these proportions are departed from, the webs are to be of equivalent strength.

Fillets and Oil Holes

633 Fillets at the junctions of crank webs with crank pins or journals are to be machined to a radius of not less than 5 per cent of the diameter of the crank shaft and are to have a smooth finish.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

Section 7

GENERAL REQUIREMENTS FOR OIL ENGINES AND STARTING AIR COMPRESSORS

General

701 Special attention is to be given to the ventilation of the engine room.

702 Cylinder relief valves are to be fitted to main engines having cylinders over 305 mm. bore. The valves

are to be loaded to not more than 40 per cent above the designed maximum pressure and are to discharge where no damage can occur.

Relief valves need not be fitted to auxiliary engines provided those having cylinders over 305 mm. bore be fitted with an approved device capable of giving warning of excessive cylinder pressure.

703 Where scavenging is effected by a single independent scavenging blower alternative or duplicate means for driving the blower are to be provided ready for use.

704 Scavenge manifolds of two-stroke main engines are to be provided with explosion relief valves.

705 The exhaust pipes and silencer are to be water cooled or efficiently lagged to prevent damage by heat; if the exhaust is led overboard near the water-line, means are to be provided to prevent water from being syphoned back to the engine.

Where the exhaust is cooled by water spray, the exhaust pipes are to be self-draining overboard.

Where the exhausts of two or more engines are led to a common silencer or exhaust gas-heated boiler or economiser an isolating device is to be provided in each exhaust pipe.

For alternatively fired furnaces of boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

In two-stroke main engines fitted with exhaust gas turbo-blowers which operate on the impulse systems, provision is to be made to prevent broken piston rings entering the turbine casing and causing damage to blades and nozzle rings.

706 An efficient governor is to be fitted to each main engine to prevent excessive racing.

707 Auxiliary engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or, when after having run on no-load for at least 15 minutes, not less than 70 per cent full load is suddenly applied, followed by the remaining 30 per cent, except in the case of emergency generators which are to be capable of accepting full load under the same test conditions. For A.C. installations, the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of $\pm 0{,}5$ per cent.

Starting Arrangements

708 Equipment for starting the main and auxiliary engines is to be provided so that the necessary initial charge of starting air or initial electric power can be developed on board ship without external aid. If for this purpose an emergency air compressor or electric generator is required, these units are to be power driven by hand starting oil engine or steam engine, except in the case of small installations where a hand operated compressor of approved capacity may be accepted. Alternatively, other devices of approved type may be accepted as a means of providing the initial start.

709 Two or more starting and manœuvring air compressors are to be fitted of sufficient total capacity for the requirements of the main engines.

The compressors are to be so designed that the temperature of the air discharged to the starting air receivers will not substantially exceed 93° C. in service. A small fusible plug or an alarm device operating at 121° C. is to be provided on each compressor to give warning of excessive air temperature. The emergency air compressor is excepted from these requirements.

Each compressor is to be fitted with a safety valve so proportioned and adjusted that the accumulation with the outlet valve closed will not exceed 10 per cent of the maximum working pressure. The casings of the cooling water spaces are to be fitted with a safety valve or bursting disc so that ample relief will be provided in the event of the bursting of an air cooler tube. It is recommended that compressors be cooled by fresh water.

710 Where the main engines are arranged for air starting the total air receiver capacity is to be sufficient to provide, without replenishment, not less than twelve consecutive starts of each main engine if of the reversible type and not less than six consecutive starts if of the non-reversible type. In passenger ships, at least two air receivers are to be provided. For scantlings and fittings of air receivers *see* J 24.

711 Where main engines are fitted with electric starters, two batteries are to be fitted. Each battery is to be capable of starting the engines when cold and the combined capacity is to be sufficient without recharging to provide the number of starts of the main engines as required by 710. In other respects batteries are to comply with the requirements of M 13.

Starting Air Pipe Systems and Safety Fittings

712 In designing the compressed air installation care is to be taken that the compressor air inlets will be located in an atmosphere reasonably free from oil vapour or alternatively an air duct from outside the machinery space is to be led to the compressors.

The air discharge pipe from the compressors is to be led direct to the starting air receivers. Provision is to be made for intercepting and draining oil and water in the air discharge for which purpose a separator or filter is to be fitted in the discharge pipe between compressors and receivers.

The starting air pipe system from receivers to main and auxiliary engines is to be entirely separate from the compressor discharge pipe system. Stop valves on the receivers are to permit of slow opening to avoid sudden pressure rises in the piping system. Valve chests and fittings in the piping system are to be of ductile material.

Drain valves for removing accumulations of oil and water are to be fitted on compressors, separators, filters, receivers and any low-level pipe lines.

The starting air piping system is to be protected against the effects of explosions by the following arrangements. An isolating non-return valve or equivalent is to be provided at the starting air supply connection to each engine. In direct reversing engines bursting discs or flame arresters are to be fitted at the starting valves on each cylinder; in non-reversing and auxiliary engines at least one such device is to be fitted at the supply inlet to the starting air manifold on each engine. The fitting of bursting discs or flame arresters may be waived in small ships where the power of the main engine is less than 1500 b.h.p. provided all the pipes in the system are made at least twice as thick as required by E 506 or E 512.

Alternative safety arrangements may be submitted for consideration.

Crank Case Safety Fittings

713 Crank cases are to be provided with lightweight spring-loaded valves or other quick-acting and self-closing devices to relieve the crank cases of pressure in the event of an internal explosion and to prevent any inrush of air thereafter. The valves are to be designed to open at a low pressure of about 0,1 kg. per cm.^{2}.

The valve lids are to be made of ductile material capable of withstanding the shock of contact with stoppers at the full open position.

In large engines at least one of these valves is to be fitted to each cylinder crank case and separate gear or chain case for camshaft or similar drive. In small engines where there is free communication between all cylinder crank cases, valves are to be provided in numbers not less than given in Table 6. Where only two valves are required they are to be located at or near each end of the crank case. In engines having cylinders of less than 150 mm. bore or crank case volumes of less than 0,57 m.^{3}, relief valves may be omitted.

The discharge from the valves is to be shielded where necessary by flame guard or flame trap to minimise the possibility of danger and damage arising from the emission of flame.

714 The minimum area of crank case relief valves is to be determined as follows:—

$$A = \frac{V \times 114}{N}$$

where A = minimum effective area of each valve, in square centimetres,

V = total gross volume of crank case in cubic metres,

N = number of relief valves fitted to each engine, which is to be not less than given in Table 6.

No valve is to be less than 75 mm. in diameter or the equivalent area.

TABLE 6

Diameter of Engine Cylinders Millimetres	Number of Cylinders per Engine	Minimum Number of Relief Valves per Engine
150 to 230	Up to 8	2
	Over 8	3
Over 230 to 305	Any Number	One for each* Alternate Cylinder
Over 305	Any Number	One per Cylinder

*For engines having 5, 7, 9, etc. cylinders, the number of relief valves is to be not less than 3, 4, 5, etc., respectively.

In general, for "V" engines half the number of cylinders may be taken in using this table.

Alarms giving warning of the overheating of engine running parts, indicators of excessive wear of thrusts and other parts, and detectors of smoke in the crank case are recommended as means for reducing the explosion hazard. These devices should be arranged to give an indication of failure of the equipment or of the instrument being switched off when the engine is running. Where approved devices of this nature are fitted, a reduction in the area of relief valves up to a maximum of 50% may be permitted subject to special approval.

715 Crank cases and their doors are to be of robust construction and the doors are to be securely fastened so that they will not be readily displaced by an explosion.

716 Where crank case vent pipes are fitted, they are to be made as small as practicable to minimise the inrush of air after an explosion. Vents from crank cases of main engines are to be led to a safe position on deck or other approved position.

Lubricating oil drain pipes from engine sump to drain tank are to be submerged at their outlet ends. Where two or more engines are installed, vent pipes, if fitted, and lubrication oil drain pipes are to be independent to avoid intercommunication between crank cases.

717 Crank cases of large starting air compressors are to be fitted with explosion relief devices as required for auxiliary engines in cases where the crank case volume is 0,57 m.^{3} and over.

Crank Case Lighting

718 Where interior lighting is provided it is to be flame proof in relation to the interior and details are to be submitted for approval. No wiring is to be fitted inside the crank case.

Hydraulic Tests

719 Where main and auxiliary engine cylinder covers and cylinders not fitted with liners cannot be readily examined internally they are to be tested by hydraulic pressure to 1,5 times the maximum working pressure.

720 Air compressor cylinders, covers, intercoolers and aftercoolers are to be tested by hydraulic pressure to twice their maximum working pressure.

721 Cylinder liners are to be tested by hydraulic pressure to not less than 7 kg. per cm.^{2}

722 The water jackets of cylinders, and the cooling passages of cylinder covers and pistons, are to be tested by hydraulic pressure to 2,1 kg. per cm.^{2}

723 Fresh water and lubricating oil coolers are to be tested by hydraulic pressure to twice the working pressure with a minimum of 3,5 kg. per cm.^{2} on the fresh water and lubricating oil side, and a minimum of 2,1 kg. per cm.^{2} on the cooling water side.

Astern Power

724 Ships are to have sufficient power for going astern to secure proper control of the ship in all normal circumstances.

Trials

725 The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions.

It is to be demonstrated that the capacity of starting air receivers is adequate to provide the required number of starts of the main engines.

In the case of passenger ships, the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manœuvring conditions, and so bring the ship to rest from maximum ahead service speed is to be demonstrated at the sea trials.

All trials are to be to the Surveyor's satisfaction.

Cross-references

726 Where auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares are to comply with the requirements of Chapter M.

727 The pumping arrangements, cooling water and lubricating oil systems are to comply with the requirements of Chapter E.

728 All oil fuel pipes, tanks and their fittings are to comply with the requirements of D 20 and Chapter E.

Spare Gear

729 For lists of spare gear to be carried, *see* Chapter K.

Periodical Surveys

730 For periodical survey requirements, *see* C 5 and C 7.

Section 8

STRENGTHENING FOR NAVIGATION IN ICE

801 Where the notation "Ice Class 1*, 1, 2 or 3" is desired, the following requirements are to be complied with, so far as these are applicable.

Power of Propelling Machinery

802 The power delivered to the propeller shafting (s.h.p.) is not to be less than $C \times L \times B$

Where L = length of ship, between perpendiculars, in metres,

B = breadth of ship, moulded, in metres,

C = 2,1 for Class 1*
1,79 for Class 1
1,31 for Class 2
0,98 for Class 3.

Main Engine Shafting

803 The shafting and couplings are to be steel and the diameters of the shafting as required by the rules for ocean-going service are to be increased by the percentages stated in Table 7. No increase in the diameter of crank shafts of oil engines is required.

Gearing

804 If gearing is fitted between the engine and propeller shafting, the gearing is to be designed and constructed to transmit torque in excess of that corresponding to the engine power by the percentages given in Table 7.

TABLE 7

Class	1*	1	2	3
Screw shaft, increase in diameter	20%	15%	8%	5%
Crank, Thrust and Intermediate Shaft, increase in diameter	12%	8%	4%	—
Gearing, torque increase ...	50%	25%	15%	—

Turbines

805 Where turbines are used for the propulsion of ships intended for Class 1*, 1 or 2 ice strengthening, the propeller shafting is to be driven by electrical or other approved means capable of protecting the turbines from shock.

Electric Motors

806 Where direct current electric motors are used for the propulsion of ships intended for Class 1 and 2 ice strengthening, provision is to be made for automatically limiting the transmitted torque to a safe value.

Propellers

807 Propellers and propeller blades are to be of cast carbon steel, alloy steel or bronze having a tensile strength of not less than 44 kg. per mm.^{2}. The material is to comply with the requirements of P 5 or P 10.

Propellers intended for Class 1*, 1, 2 and 3 ice strengthening are to be designed so that the blade root thickness at 25 per cent radius for solid propellers and at 35 per cent radius for controllable pitch propellers is not less than obtained by the following formula:—

$$T = 25{,}4 \times K \sqrt{\frac{SHP \times 44}{R \times S \times N \times L}} \text{ millimetres,}$$

$$\text{where } K = C - \frac{EP}{D} + \frac{FAR}{D}$$

T = blade root thickness, in millimetres,

SHP = maximum designed shaft horse power,

R = revolutions per minute of propeller, at maximum power,

D = propeller diameter, in millimetres,

P = mean pitch at maximum power rating, in millimetres,

L = length of blade section, in millimetres,

A = rake, in millimetres,

N = number of blades,

C, E and F = coefficients given in Table 8,

S = tensile strength of material, in kg. per mm.^{2}

The thickness t of the blade at 95 per cent radius is to be not less than obtained by the following formula for Class 1*, 1, 2 and 3 ice strengthening:—

$$t = (G \times T + 8) \sqrt[3]{\frac{44}{S}} \text{ millimetres}$$

where G = 0,14 for solid propellers,

= 0,155 for controllable pitch propellers.

For Class 1* and Class 1 propellers, the blade thicknesses at sections between the root (i.e. at 25 per cent radius or 35 per cent radius as applicable) and 95 per cent radius are to be not less than included by the straight lines joining thicknesses T and t. For Class 2 and Class 3 propellers, the thicknesses of sections in the region of the mid-radius of the blade may be reduced below that included by the straight lines joining thicknesses T and t by 5 per cent and 10 per cent respectively.

Alternatively, a detailed stress computation for the blades is to be submitted for consideration.

The edges of the blades are to be suitably thickened for the operating conditions but are to be not less than 50 per cent of the required tip thickness t, measured at 1,25 times tip thickness t from the edge. For controllable pitch propellers, this requirement need only be applied to the leading edges of the blades.

A plan, in triplicate, of the propeller, together with details of the material, power and revolutions per minute

and other particulars required for calculating the Rule thicknesses of the blades, are to be submitted for approval by the propeller designers.

TABLE 8

Propeller Type	Ice Class	Coefficients		
		C	E	F
Solid	1*	118	30	0,7
	1	111	30	0,7
	2	103	30	0,7
	3	98	30	0,7
Controllable Pitch	1*	107	27,5	0,63
	1	100	27,5	0,63
	2	93	27,5	0,63
	3	88	27,5	0,63

Ship Side Valves

808 All sea inlet and overboard discharge valves are to be provided with a low pressure steam system or other ice melting means for clearing purposes. *See* E 271.

809 Connections are to be fitted between the cooling water overboard discharge lines and sea inlets for main and auxiliary engine cooling water systems so that warm water may be used to assist in maintaining the suction pipes free from ice.

Where the cooling water inlet valves are fitted to a common water box, the connection from the cooling water discharge line may be led to the water box in a position as near as possible to the inlet valves.

810 In motor ships where clearing steam is not available fire pumps are to be provided with suctions from the main cooling water inlet pipe.

Cross-references

811 For hull requirements *see* D 10 and for general requirements for ship side valves, *see* E 267 to E 271.

Section 9

WELDED STRUCTURES FOR STEAM RECIPROCATING AND OIL ENGINES

General

901 The requirements of this section are applicable to engines for main propelling purposes.

Plans

902 Before construction is commenced plans of bedplates, crankcases, frames and entablatures, including details of the welded joints, materials, electrodes and heat treatment are to be submitted for consideration.

An outline of the welding procedure and fabrication method and sequence is also to be submitted for information.

NOTE: It will not be necessary for plans and particulars to be submitted for each ship provided the basis plans for the engine size and type have previously been approved as meeting the requirements of these Rules. Any alterations to basis design, materials and manufacturing procedure are to be re-submitted for consideration.

Materials

903 Plates, sections, forgings and castings are to be of welding quality to an approved specification with a carbon content generally not exceeding 0,23 per cent, and are to be tested in accordance with the requirements of Chapter P. Steels with higher carbon contents may be approved subject to special tests to prove weldability.

Welded Joints

904 Joints in parts of the engine structure which are stressed by the main gas, steam or inertia loads are to be designed as continuous full strength welds and for complete fusion of the joint. They are to be so arranged that, in general, welds do not intersect, and that welding and inspection can be effected without difficulty. Abrupt changes in plate section are to be avoided and where plates of substantially unequal thickness are to be butt welded, the thickness of the heavier plate is to be gradually tapered to that of the thinner plate. Tee joints are to be made with full bevel or equivalent weld preparation to ensure full penetration.

In single plate transverse girders the castings for main bearing housings are to be formed with web extensions which can be butt welded to the flange and vertical web plates of the girder. Stiffeners in the transverse girder are to be attached to the flanges by full penetration welds.

Construction

905 Plates and weld preparations are to be accurately machined or flame-cut to shape. Flame-cut surfaces are to be cleaned by machining or grinding; if the flame-cut surfaces are smooth, wire brushing may be accepted.

Before welding is commenced the component parts of bedplates and framework are to be accurately fitted and aligned. The welding is to be done in positions free from draughts and is to be downhand wherever practicable. Electrodes are to be of an approved type. Pre-heating is to be adopted when welding heavy plates or sections. The finished welds are to have an even surface and be free from

undercutting. Welds attaching bearing housings to the transverse girders are to have a smooth contour and if necessary are to be made smooth by grinding.

Heat Treatment

906 Bedplates of oil engines are to be stress relieved except for engine types where the bedplate as a whole is not subjected to direct loading from the cylinder pressure. For the latter types, and for all steam engines, only the transverse girder assemblies need be stress relieved.

Stress relieving is to be done by heating the welded structure uniformly and slowly to a temperature between 600° C. to 650° C. (1112° F. to 1202° F.), holding that temperature for not less than one hour per 25 mm. of maximum plate thickness and thereafter allowing the structure to cool slowly in the furnace.

Inspection

907 Welded engine structures are to be examined during fabrication, special attention being given to the fit of component parts of major joints prior to welding. On completion of welding and stress relieving, all welds are to be examined. Welds in transverse girder assemblies are to be crack detected by an approved method to the satisfaction of the Surveyors. Other joints are to be similarly tested if required by the Surveyors.

The whole of the welding work is to be to the satisfaction of the Surveyors.

Design Recommendations

It is recommended that bedplates and major components of engine structures should be made with a minimum number of welded joints.

Double welded butt type joints should be adopted wherever possible in view of their superior fatigue strength.

Girder and frame assemblies should, as far as possible, be made from one plate or slab, shaped as necessary, rather than by welding together a number of small pieces.

Steel castings should be used for parts which would otherwise require complicated weldments.

Care should be taken to avoid stress concentrations such as sharp corners and abrupt changes in section.

16th June, 1966

Chapter J

BOILERS AND OTHER PRESSURE VESSELS

CYLINDRICAL BOILERS

Section 1

GENERAL REQUIREMENTS

101 In the design and construction of boilers the following conditions are to be observed.

102 The materials used are to be in accordance with the relevant requirements of Chapter P.

103 Where the joints in the shells of boilers are made by means of welding, the shells are to be constructed in accordance with the requirements of J 16, J 18, J 19 and J 22, in so far as they are applicable.

104 Where the joints in the shells of boilers are riveted, the shells are to be constructed in accordance with the requirements of J 5.

105 All steel plates which are welded, dished, flanged or locally heated are to be afterwards efficiently heat treated.

106 Butt straps are to be cut from plates and not from rolled strips.

107 All rivet holes are to be drilled, and as far as possible they are to be drilled in place. After drilling the plates the burrs are to be removed and the faying surfaces of the plates cleaned, and the sharp outer edges of holes also removed.

108 Steel stays are not to be welded. If plus threads are desired, the ends of the stay bars may be upset or the bars may be drawn down in the central portions from bars originally of the size of the ends. In either of these two cases the bars are to be subsequently annealed throughout. In double-ended boilers the through longitudinal stays are to be supported at or near the middle of their length.

109 Screw stays of combustion chambers where fitted with nuts are to be, as far as possible, normal to the chamber plates. Where this is not possible they are to be fitted with taper washers to provide a fair bed for the nuts.

110 Nuts to screw stays in combustion chambers are to be not less than 19 mm. thick for stays up to 38 mm. diameter over threads, 22 mm. thick for 41 and 45 mm. stays, 25 mm. thick for 48 and 51 mm. stays, and 29 mm. thick for stays over 51 mm. in diameter. The nuts are to be made of solid mild steel or of iron which is to be without weld.

111 Screw stays 32 mm. in diameter and above should have 9 threads per 25,4 mm., and all stays 51 mm. in diameter and above passing through plates, and secured by nuts on each side of the plate, should have not more than 6 threads per 25,4 mm.

112 Where jointed longitudinal stays are fitted between the front and back tube plates they are to be fitted with pins having an effective sectional area not less than 25 per cent in excess of that of the stay. The pins may be slack in the holes, the total slackness being not more than 1,5 mm. The pins are to be as close as possible to the shoulder of the eye forging. The shoulder of the forging is to have a diameter not less than 25 mm. greater than the diameter of the hole.

113 The end plates in the steam space in way of uptakes are to be shielded from contact with the heated gases.

Cross-reference

114 For requirements as to smoke box doors and the omission of dampers in oil-fired boilers, *see* E 332 and E 333.

Section 2

ACCESS ARRANGEMENTS

201 Manholes in cylindrical shells are to have their shorter axes arranged longitudinally. Where the cylindrical shell is cut for a manhole, compensation is to be provided and is to be such that the strength in way of the hole is not less than that required for the longitudinal joint.

202 Where a flat plate is flanged for stiffening it at a manhole or sight hole, to permit the same working pressure as would be allowed upon an unpierced plate, the depth of the flange measured in millimetres from the outer surface is to be at least equal to $\sqrt{T \times W}$ where T is the thickness of the plate in millimetres and W is the minor axis of the hole in millimetres.

203 The doors to manholes, mudholes, and sight holes are to be built up or pressed to shape and annealed, or made from one thickness of plate with a machined recess for the jointing material. Their spigot part or the recess is not to have a greater clearance than 1,5 mm. all round, i.e., the axes of the opening are not to exceed those of the door by more than 3 mm.

204 The studs for securing all doors are to be screwed through the plate, and they are to be fitted with nuts on the inside or bolts may be used screwed through the plate with the heads inside.

205 All boilers are to be provided, where possible, with means for ingress to permit of examination and cleaning of the inner surfaces of plates and tubes exposed to flame. Where the boilers are too small to permit of this there are to be sight holes and mudholes sufficiently large and numerous to permit of the inside being satisfactorily cleaned.

206 Where the cross tubes of vertical boilers are large there is to be a sight hole in the shell opposite to one end of each tube sufficiently large to permit the tube to be examined and cleaned. These sight holes are to be in positions accessible for that purpose.

Section 3

HYDRAULIC TESTS

Boilers

301 In all new boilers working at pressures up to 7 kg. per cm.^{2} the hydraulic test is to be twice the working pressure. For boilers working at pressures greater than 7 kg. per cm.^{2} the hydraulic test pressure is to be 1,5 times the working pressure plus 3,5 kg. per cm.^{2}

Boiler Mountings

302 All boiler mountings are to be subjected to a hydraulic test of twice the working pressure with the exception of feed check valves which are to be tested to 2,5 times the working pressure. The test pressures need not, however, be more than 70 kg. per cm.^{2} above the working pressure.

Section 4

MOUNTINGS AND FITTINGS FOR CYLINDRICAL AND VERTICAL BOILERS AND UNFIRED STEAM GENERATORS

General

401 Valves over 38 mm. diameter are to be fitted with outside screws and the covers are to be secured by bolts or studs. All valves are to be arranged to be shut with a right-hand (clockwise) motion of the wheels.

402 All cocks and valves connected to the boiler are to be such that it is seen without difficulty whether they are open or shut. Where boiler mountings are secured by studs, the studs are to have a full thread holding in the plate for a length of at least one diameter. If the stud hole penetrates the whole thickness of the plate the stud is to be screwed right through the plate and is to be fitted with a nut inside the boiler. Where bolts are used for securing mountings they are to be screwed right through the plate with their heads inside the boiler.

403 Where a superheater is fitted which can be shut off from the boiler it is to be provided with a separate safety valve fitted with easing gear. The valve as regards construction is to comply with the regulations for ordinary safety valves, but the easing gear may be fitted to be workable from the stokehold only. The superheater is also to be fitted with a drain cock or valve to free it from water when necessary.

404 Safety valve chests and other boiler and superheater mountings subjected to pressures exceeding 10,5 kg. per cm.^{2} or to steam temperatures exceeding 218° C., and boiler blow down fittings, are to be made of steel or other approved material.

Safety Valves

405 Boilers and unfired steam generators are to be fitted with not less than two safety valves, each having a minimum diameter of 38 mm., but those having a total heating surface of less than 9,3m.^{2} may have one valve not less than 50 mm. diameter.

406 The valves, spindles, springs and compression screws are to be so encased and locked that the safety valves and pilot valves, after setting to the working pressure, cannot be tampered with or overloaded in service; the spring casing of superheater safety valves should be ventilated or other arrangement provided to protect the springs from excessive temperature.

Valves are to be so designed that in the event of fracture of springs they cannot lift out of their seats. For safety valves operating at pressures below 17,6 kg. per cm.^{2} it should, in general, be possible for the valves to be turned round on their seats by hand.

Easing gear is to be provided for lifting the safety valves and is to be operable by mechanical means at a safe position from the boiler or engine room platforms.

Safety valves are to be made with working parts having ample clearances to ensure complete freedom of movement. Valve seats are to be effectively secured in position. Any adjusting devices which control discharge capacity are to be positively secured so that the adjustment will not be affected when the safety valves are dismantled at surveys.

407 All the safety valves of each boiler and unfired steam generator may be fitted in one chest, which is to be separate from any other valve chest and is to be connected

directly to the shell by a strong and stiff neck, the passage through which is to be of not less cross sectional area than the aggregate area of the safety valves in the chest in the case of full lift valves and one-half of that area in the case of other valves. For meaning of aggregate area *see* 408.

Each safety valve chest is to be drained by a pipe fitted to the lowest part and led with a continuous fall to the bilge or to a tank, clear of the boilers. No cocks or valves are to be fitted to these drain pipes. It is recommended that the bore of the drain pipes be not less than 19 mm.

SATURATED STEAM

408 The minimum aggregate area of the orifices through the seatings of the safety valves on each boiler and unfired steam generator is to be found by the following formula:—

$$A = \frac{E \times C}{p + 1{,}05}$$

where A = *for ordinary, high lift or improved high lift safety valves*, the aggregate area in mm.^{2} of the orifices through the seatings of the valves, neglecting the area of guides and other obstructions,

= *for full lift safety valves*, the net aggregate area in mm.^{2} through the seats after deducting the area of the guides or other obstructions when the valves are fully lifted,

p = working pressure, in kg. per cm.^{2} gauge,

E = designed evaporation, in kg. per hour. In no case shall the designed evaporation be based on less than 29 kg. per m.^{2} of heating surface per hour for coal or oil fired boilers and 14,5 kg. per m.^{2} per hour for exhaust gas heated boilers.

C = 21 for valves of ordinary type having a minimum lift of D/24,
14 for valves of high lift type, having a minimum lift of D/16,
10,5 for valves of improved high lift type having a minimum lift of D/12,
5,25 for valves of full lift type having a minimum lift of D/4,

D = bore of valve seat, in millimetres.

When the discharge capacity of a safety valve of approved design has been established by type tests, carried out in the presence of the Surveyors or by an independent authority recognised by the Society, on valves representative of the range of sizes and pressures intended for marine application, consideration will be given to the use of a lower constant than C=5,25 based on 90 per cent of the measured capacity down to a minimum of C=2,24 for full lift safety valves.

SUPERHEATED STEAM

409 For valves which have to pass superheated steam, the aggregate area of the valves is to be the area A required by 408, multiplied by the factor:—

$$(1 + 0{,}0018T)$$

where T = degree of superheat, in degrees Centigrade.

Unfired Steam Generators

410 Steam heated steam generators are to be protected from excessive pressure resulting from any failure of the high pressure heating tubes. For this purpose, the area of safety valves obtained by the formula in 408 may require to be increased unless other protective devices are provided to control the supply of steam to the heating tubes.

Waste Steam Pipe

411 For ordinary, high lift and improved high lift type valves, the cross-sectional area of the waste steam pipe and passages leading to it, is to be at least 10 per cent greater than the aggregate area of the safety valves as calculated by the foregoing formulæ. For other valves the cross-sectional area of the waste steam pipe and passages is to be not less than $\frac{10}{C}$ times the aggregate valve area.

The cross-sectional area of the main waste steam pipe is to be not less than the combined cross-sectional areas of the branch waste steam pipes leading thereto from the boiler safety valves.

Waste steam pipes from boilers and unfired steam generators are to be led to the atmosphere and are to be adequately supported and provided with suitable expansion joints, bends or other means to relieve the safety valve chests of undue loading.

The scantlings of waste steam pipes and silencers are to be suitable for the maximum pressure to which the pipes may be subjected in service and not less than $\frac{1}{4}$ of the pressure to which the valves are to be set.

Silencers fitted to waste steam pipes are to be so designed that the clear area through the baffle plates is not less than that required for the pipes.

The safety valves of each exhaust gas heated economiser and each exhaust gas heated boiler which may be used as an economiser are to be provided with entirely separate waste steam pipes.

External drains and exhaust steam vents to atmosphere are not to be led to waste steam pipes.

It is recommended that a scale trap and means for cleaning be provided at the base of each waste steam pipe to the Surveyors' satisfaction.

Accumulation Tests

412 All safety valves are to be set under steam to a pressure not greater than 3 per cent above the approved working pressure of the boiler. During a test of 15 minutes with the stop valves closed and under full firing conditions the accumulation of pressure is not to exceed 10 per cent of the loaded pressure. During this test no more feed water should be supplied than is necessary to maintain a safe-working water level.

413 For accumulation tests on the safety valves of water tube boilers, *see* J 1703 and J 1704.

Stop Valves

414 One main stop valve is to be fitted to each boiler secured direct to the shell. There are to be as few auxiliary stop valves as possible so as to avoid piercing the boiler shell more than is absolutely necessary. The arrangement, however, is to be such that where more than one boiler is fitted it is possible to supply the steam whistle, the steam steering gear, and the electric light machinery from at least two boilers.

Water Level Indicators on Cylindrical Boilers

415 Every boiler is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a glass gauge. The other means is to be either an additional glass gauge or an approved equivalent device.

On double-ended boilers the above two water level indicators are to be fitted at each end, one indicator being positioned on each side.

On single-ended boilers, the water level indicators are also to be fitted one on each side of the boiler.

416 A set of not less than two test cocks will be accepted as the approved equivalent device mentioned in 415, for boilers having a working pressure less than 8,4 kg. per $cm.^2$ or an internal diameter less than 1,83 metres.

The test cocks are to be fitted, where practicable, direct to the boiler plating.

417 The water gauges are to be readily accessible and placed so that the water level is clearly visible.

The lowest visible part of the glass of the water gauge and the lower test cock, where test cocks are fitted, are to be situated at the lowest safe working water level.

418 The level of the highest part of the effective heating surfaces, e.g., combustion chamber top of a horizontal boiler and the furnace crown of a vertical boiler, is to be clearly marked in a position adjacent to the glass water gauge.

419 The cocks of all water gauges are to be accessible from positions free from danger in the event of the glass breaking.

420 If the water gauges are not fitted directly to the shell of the boiler but to stand pillars or columns, it is desirable that these pillars or columns should be bolted directly to the shell of the boiler. If they are connected to the boiler by means of pipes the pipes are to be fitted with terminal cocks, not valves, secured direct to the boiler shell. For boilers exceeding 3 metres in diameter the pillars are to be not less than 63 mm. and the connecting pipes not less than 38 mm. internal diameter. For boilers exceeding 2,30 metres but not exceeding 3 metres in diameter the pillars are to be not less than 50 mm. and the pipes not less than 32 mm. internal diameter, and for boilers 2,30 metres in diameter and under the pillars are to be not less than 45 mm. and the pipes not less than 25 mm. internal diameter. The upper ends of the connecting pipes are to be so arranged that there is no pocket or bend where an accumulation of water from the condensation of the steam can lodge. They should not pass through the uptake if they can be otherwise arranged. If, however, this condition cannot be complied with, they may pass through it by means of a passage at least 50 mm. clear of the pipe all round, open for ventilation.

421 For water level indicators on water tube boilers, *see* J 1706 and J 1707.

Feed Check Valves

422 Two feed check valves, connected to separate feed lines, are to be provided for all main, auxiliary and donkey boilers which are required for essential services with the exception of boilers in which steam is generated exclusively by exhaust gas or steam, where one feed check valve will be accepted. (*See* E 701.)

The feed check valves are to be attached, wherever practicable, direct to the boiler but where the arrangements necessitate the use of standpipes between the boiler and the check valves, these pipes are to be of steel or other approved material.

423 For boiler feed water systems, *see* E 7, and for feed water fittings on water tube boilers, *see* J 1708 and J 1709.

Pressure Gauges

424 Each boiler is to be provided with a separate steam pressure gauge. Double-ended boilers are to be provided with a pressure gauge at each end. The gauges are to be placed where they are easily seen.

Blow-down and Scum Valves

425 Each boiler is to be fitted with at least one blow-down valve secured direct to the lower part of the boiler.

Where it is not practicable to attach the blow-down valve direct to water tube boilers, the valve may be placed immediately outside the boiler casing with a steel pipe of substantial thickness fitted between the boiler and valve. The pipe and valve are to be suitably supported and any pipe which may be exposed to direct heat from the furnace is to be adequately protected.

The blow-down valve and its connections to the sea need not be more than 38 mm. and is to be not less than 20 mm. in diameter. For cylindrical boilers the size of the valve may be generally 8,5 mm. in diameter for each metre in diameter of the boiler.

Vertical boilers are to be fitted with a blow-down valve or cock.

426 Blow-down valves and scum valves (where these latter are fitted) of two or more boilers may be connected to one common discharge, but where thus arranged there are to be screw-down non-return valves fitted for each boiler to prevent the possibility of the contents of one boiler passing to another.

For blow-down cock or valve on ship's side and attachments, *see* E 267 and E 268.

Salinometer Cock or Valve

427 Each boiler is to be provided with a salinometer cock or valve secured direct to the boiler in a convenient position. The cock or valve is not to be on the water gauge standpipe.

Section 5

RIVETED CYLINDRICAL SHELLS

501 For the cylindrical shells of steel marine boilers the maximum working pressure is to be calculated from the following formula:—

$$WP = \frac{(t-1,6) \times S \times J}{1,92 \times D}$$

where WP = maximum working pressure in kg. per cm.^{2},

t = thickness of the shell plates, in millimetres,

S = minimum tensile strength of the steel shell plates, in kg. per mm.^{2},

J = percentage of strength of the longitudinal seams, with double butt straps, calculated by the methods described in 502,

D = inside diameter of the outer strake of plating of the cylindrical shell, measured in millimetres.

502 The percentage of strength of a riveted joint (J) is found from the following formulæ, the first two being applicable to any type of joint, and the third to that type of joint in which the number of rivets in the inner rows is double that in the outer row. The lowest value given by the application of these formulæ is to be taken as the percentage of strength of the joint.

$$\left.\begin{array}{l}\text{Percentage of strength of plate at joint as compared with solid plate}\end{array}\right\} = \frac{100\,(p-d)}{p}$$

$$\left.\begin{array}{l}\text{Percentage of strength of rivets as compared with solid plate}\end{array}\right\} = \frac{100\,(S_2 \times a \times n \times C)}{S_1 \times p \times T}$$

Percentage of combined strength of the plate at the inner row of rivet holes and of the rivets in the outer row

$$= \frac{100\,(p-2d)}{p} + \frac{100\,(S_2 \times a \times C)}{S_1 \times p \times T}$$

Where p = pitch of rivets at outer rows, in millimetres,

d = diameter of rivet holes, in millimetres,

a = sectional area of one rivet, in mm.^{2},

n = number of rivets which are fitted in the pitch p,

T = thickness of plate, in millimetres,

S_1 = minimum tensile strength of plates, in kg. per mm.^{2},

S_2 = shearing strength of rivets, which is taken generally to be 36 kg. per mm.^{2}, and may be 85 per cent of the minimum tensile strength of the rivet bars,

C = 1,0 for rivets in single shear as in lap circumferential joints, 1,875 for rivets in double shear as in double butt-strapped longitudinal joints.

503 All longitudinal seams are to be butt jointed with double butt straps; the outer butt strap is to be at least 0,625 of the strength of the plate and of sufficient thickness to permit of efficient caulking of its outer edges. The inner butt strap is to be 3 mm. thicker than this.

In cases where the number of rivets in the inner rows is double the number in the outer row, this will require the

minimum thickness, in millimetres, of the outer strap (t_o) to be

$$t_o = \frac{5 \times (p-d)}{8 \times (p-2\,d)} \times T$$

and that of the inner strap (t_n) to be

$$t_n = \left\{ \frac{5 \times (p-d)}{8 \times (p-2\,d)} \times T \right\} + 3\,\text{mm.}$$

504 In all cases the clear space between a rivet hole and the edge of a plate is to be not less than the diameter of the rivet holes, i.e., the centre of the rivet hole is to be at least 1,5 diameters distant from the edge of the plate.

In the joints whether lapped or fitted with butt straps, in which there are more than one row of rivets and in which there is an equal number of rivets in each row, the distance between the rows of rivets is to be not less than 0,33 p + 0,67 d with zigzag riveting, or 2 d with chain riveting.

In joints in which the number of rivets in the outer rows is one half of the number in each of the inner rows, and in which the inner rows are chain riveted, the distance between the outer rows and the next rows is to be not less than 0,33 p + 0,67 d or 2 d, whichever is the greater, and the distance between the rows in which there are the full number of rivets is to be not less than 2 d.

In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows and in which the inner rows are zigzag, the distance between the outer rows and the next rows is to be not less than 0,2 p + 1,15 d, and the distance between the rows in which there are the full number of rivets is to be not less than 0,165 p + 0,67 d.

In the above p is the pitch of the rivets in the outer rows.

505 The maximum pitch, in millimetres, of the rivets in the longitudinal seams, with double butt straps, of boiler shells

$$= (C \times T) + 40\ \text{mm},$$

where T is the thickness of the plate in millimetres and C is a coefficient as given in the following Table:—

Number of rivets per pitch	Coefficients C
1	1,75
2	3,50
3	4,63
4	5,52
5	6,00

506 If holes are cut in the cylindrical shells of boilers for fixing of mountings, the diameters of the holes being greater than 2,5 times the thickness of the shell plating plus 70 mm., compensation is to be fitted as in the case of manholes. (*See* J 201.)

507 Where more than three screw stays pierce the cylindrical shell in a horizontal line, if d is their diameter and p the pitch, $\frac{100\,(p-d)}{p}$ should not be less than the percentage of strength required for the shell longitudinal joints. If this is not possible, stays are to be arranged out of line with one another longitudinally.

508 The strength of the seams joining the end plates to the cylindrical shell is not to be less than 42 per cent of that of the solid shell plate. Where the shell plates exceed 16 mm. in thickness the seams connecting the shell plates to the end plates are to be at least double riveted. Where the shell plates exceed 13 mm. in thickness the intermediate circumferential seams of double-ended boilers are to be at least double riveted.

509 The circumferential seam at or near the middle of the length of single-ended boilers is to have a strength of joint not less than 60 per cent of the solid plate. The inner circumferential seams of double-ended boilers are to have a strength of joint not less than 62 per cent of the solid plate. In any case there are to be at least three rows of rivets where single-ended boilers have shell plates over 35 mm. in thickness and where double-ended boilers have shell plates over 30 mm. in thickness.

510 The circumferential seams of the shells of vertical boilers are to have a strength of not less than 42 per cent of the solid plate. Where these seams are not complete circles, and where the shell plates exceed 16 mm. in thickness, the riveting is to be at least double.

Section 6

FURNACES

Note:—Furnaces, plain or corrugated, are not to exceed 21 mm. in thickness.

Corrugated Furnaces

601 The working pressure to be allowed on corrugated furnaces is to be determined by the following formula:—

$$WP = \frac{C\,(t-0{,}8)}{D}$$

where WP = working pressure, in kg. per cm.2,
D = external diameter measured at the bottom of the corrugations, in millimetres,
t = thickness of the furnace plate, in millimetres, measured at the bottom of the corrugations or camber,

C = 1080 for the Fox, Morison, Deighton, Purves and other similar furnaces, 1150 for the Leeds Forge Bulb Suspension furnace.

Plain Furnaces and Combustion Chamber Bottoms

602 The working pressure to be allowed on plain furnaces or furnaces strengthened by the Adamson or other joints, and on the cylindrical bottoms of combustion chambers, is to be determined by the following formulæ, the least pressure obtained by either formula being taken:—

$$WP = \frac{C\,(t-0{,}8)^2}{(L + 610) \times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [320\,(t-0{,}8) - L]$$

where WP = working pressure, in kg. per cm.^{2},
D = external diameter of the furnace or combustion chamber, in millimetres,
t = thickness of the plate, in millimetres,
L = length of the furnace or of combustion chamber bottom or the length between points of substantial support, in millimetres, measured from the centres of the rivet rows or from the commencement of flange curvature, whichever is applicable,
C = 104400 where the longitudinal seams are welded and 93600 where they are riveted,
C_1 = 3,5 where the longitudinal seams are welded and 3,16 where they are riveted.

603 Where the furnaces are tapered, the diameter to be taken for calculation purposes is to be the mean of that at the top and of that at the bottom where it meets the substantial support from flange or ring. The length for the same purpose is to be the distance from the centre of the row of rivets connecting the crown to the body of the furnace, to the substantial support at the bottom of the furnace or to a row of screwed stays connecting the furnace to the shell, provided the pitch of stays at the furnace does not exceed 14 times the thickness of the furnace plate where the stays are riveted at their ends, and 16 times where they are fitted with nuts. Such screwed stays are to be in diameter over the threads not less than 2,25 times the thickness of the furnace plate.

Furnaces of Spherical Form

604 Where the furnaces are spherical in form and convex upwards at their tops, and are without support from stays of any kind:—

$$WP = \frac{620\,(t - 0{,}8)}{R}$$

where WP = working pressure, in kg. per cm.^{2},
t = thickness of the top plate, in millimetres,
R = outer radius of curvature of the furnace, in millimetres.

Uptakes of Vertical Boilers

605 The working pressure to be allowed on internal uptakes of vertical boilers is to be determined by the following formulæ, the least pressure obtained by either formula being taken:—

$$WP = \frac{C\,(t-4)^2}{(L + 610) \times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [320\,(t-4) - L]$$

where WP = working pressure, in kg. per cm.^{2},
D = external diameter of the uptake, in millimetres,
t = thickness of the uptake, in millimetres,
L = length of the uptake between points of substantial support, in millimetres, measured from the centres of the rivet rows,
C = 104400 where the longitudinal seams are welded and 93600 where they are riveted,
C_1 = 3,5 where the longitudinal seams are welded and 3,16 where they are riveted.

Cross Tubes

606 The thickness of cross tubes in cross tube boilers is to be determined from the following formula, but is in no case to be less than 9,5 mm.:—

$$t = \frac{WP \times D}{450} + 5{,}6$$

where WP = working pressure, in kg. per cm.^{2},
t = minimum thickness, in millimetres,
D = internal diameter of the cross tube, in millimetres.

Ogee Rings

607 For the ogee ring which connects the bottom of the furnace to the shell, and sustains the whole load on the furnace vertically:—

$$WP = \frac{10100\,(t-0{,}8)^2}{D \times (D - d)}$$

where WP = working pressure, in kg. per cm.^{2},
t = thickness of the ogee ring, in millimetres,
D = inside diameter of the boiler shell, in millimetres,
d = outside diameter of the lower part of the furnace where it joins the ogee ring, in millimetres.

Section 7

FLAT PLATES SUPPORTED BY STAYS SECURED IN VARIOUS WAYS

701 The working pressure to be allowed on flat plates supported by stays is to be calculated by the following formula:—

$$WP = \frac{(t - 0,8)^2 \times C}{a^2 + b^2}$$

In this formula and in the formulæ in 708 to 711

WP = working pressure, in kg. per cm.2,

t = thickness of the flat plate, in millimetres,

t_w = thickness of the washers, strips, or doublings employed, in millimetres,

a = distance apart of the rows of stays, in millimetres,

b = pitch of the stays in the rows, in millimetres,

C is a coefficient which varies with the method of fixing the stays as follows:—

Where the plates are exposed to flame and the stays are screwed into the plate and their ends are riveted over C = 3600. Where the plates are not exposed to flame and the stays are screwed into the plate and their ends are riveted over C = 4100. In these cases the thickness of the plate is to be at least half the diameter of the stay required by the Rules.

Where stay tubes are screwed into tube plates and expanded C = 3740. If they are fitted with nuts C = 5180.

Where the plates are exposed to flame and the stays are screwed into the plate and fitted with nuts on the outside C = 5400. Where the plates are not exposed to flame C = 6200.

Where the stays pass through the plates not exposed to flame and are fitted with nuts inside and outside C = 6900, and where the plates are exposed to flame C = 6050.

702 Where plates are stiffened by flanging, the inner radius of which is not greater than 2,5 times the thickness of the plate, for the support thus given C = 7900 where the plates are not exposed to flame and C = 6900 where they are exposed to flame. The pitch is to be reckoned from the commencement of the curvature.

703 For portions of plate where the stays are irregularly pitched d^2 is to be used instead of $a^2 + b^2$, d being the diameter of the largest circle which can be drawn passing through not less than three points of support, i.e., the centres of stays or the commencement of the curvature of flanging whichever is applicable. In this case C is to be taken as the mean of the values appropriate for the points of support.

704 For the tops and sides of combustion chambers the distance between the rows of stays nearest to the back tube plate or the back plate respectively and the commencement of curvature of these plates at their flanges is to be not greater than a.

705 The stays of the combustion chambers are to be so placed that the seams of the plates can be caulked without removing the stay nuts.

706 For the tops of combustion chambers where they are joined to the sides by curved portions, if the outer radius of the curved portion is less than half the allowable distance between the girders, the distance between the first girder and the inner surface of the side plate is not to exceed the allowable distance between the girders. If the radius of the curved portion is greater than half the allowable distance between the girders, the width of the flat portion measured from the centre of the girder is to be not more than half the allowable distance between the girders.

707 Where portions of plate are supported by stays secured in different ways the value of C to be taken is the mean of the values appropriate to the method of securing the supporting stays.

708 Where the plate is supported by stays which pass through it and are fitted with nuts inside and washers and nuts outside, the diameter of the washers being at least 3,5 times that of the stay, and their thickness at least two-thirds of that of the plate but not greater than that of the plate:—

$$WP = \frac{7200}{a^2 + b^2} [(t - 0,8)^2 + 0,15\ t_w^2]$$

709 Where the washers have a diameter of at least two-thirds of the pitch of the stays and a thickness of at least two-thirds of the thickness of the plate but not greater than that of the plate and are riveted to the plate in an efficient manner:—

$$WP = \frac{7200}{a^2 + b^2} [(t - 0,8)^2 + 0,35\ t_w^2]$$

710 Where the plate is stiffened by strips at least two-thirds of the pitch of the stays in breadth and having a thickness at least two-thirds of that of the plate but not greater than that of the plate and which are riveted to the plate in an efficient manner:—

$$WP = \frac{7200}{a^2 + b^2} [(t - 0,8)^2 + 0,55\ t_w^2]$$

711 Where the plate is fitted with doubling plates having a thickness of at least two-thirds of that of the plate but not greater than that of the plate and which are riveted to the plate in an efficient manner:—

$$WP = \frac{7200}{a^2 + b^2} [(t - 0,8)^2 + 0,85\ t_w^2]$$

712 For the portions of tube plates in the nests of tubes:—

$$WP = \frac{C\,(t - 0{,}8)^2}{p^2}$$

where WP = working pressure, in kg. per cm.^{2},
t = thickness of the tube plate, in millimetres,
p = mean pitch, in millimetres, of the stay tubes supporting any portions of the plate (being the sum of the four sides of the quadrilateral divided by 4),
C = 2740 where the stay tubes are screwed and expanded into the plate and nuts are not fitted,
3530 where the stay tubes are screwed and expanded into the plate and fitted with nuts. (*See* J 1206.)

713 For the wide water spaces of front tube plates between the nests of tubes and between the wing rows of tubes and the shell:—

$$WP = \frac{C[(t - 0{,}8)^2 + 0{,}55\ t_w{}^2]}{a^2 + b^2}$$

where WP = working pressure, in kg. per cm.^{2},
t = thickness of the front tube plate, in millimetres,
t_w = thickness of the doubling plate, where so fitted, in millimetres,
a = horizontal pitch of stay tubes, in millimetres, measured across the wide water space,
b = vertical pitch of stay tubes in the bounding rows, in millimetres, measured from centre to centre,
C = 3740 where the stay tubes are screwed and expanded into the tube plate and nuts are not fitted,
5180 where the stay tubes are screwed and expanded into the tube plate, and nuts are fitted to each stay tube,
4540 where the stay tubes are screwed and expanded into the tube plate, and nuts are fitted only to alternate stay tubes.

714 If steel of less strength than 41 kg. per mm.^{2} is used for flat plates, the working pressure allowed is to be correspondingly reduced.

Section 8

TUBE PLATES UNDER COMPRESSION

801 The pressure to be allowed on tube plates is to be calculated by the following formula, in which the compressive stress is taken at 9,8 kg. per mm.^{2}:—

$$WP = 1970 \times \frac{(D - d) \times t}{W \times D}$$

where WP = working pressure, in kg. per cm.^{2},
t = thickness of the tube plate, in millimetres,
D = horizontal distance apart of the tubes centre to centre, in millimetres,
d = internal diameter of the plain tubes, in millimetres,
W = width of combustion chamber, in millimetres, measured inside from tube plate to back chamber plate, or between tube plates in double-ended boilers with combustion chambers common to two opposite furnaces.

Section 9

TUBE PLATES OF VERTICAL BOILERS

901 Where vertical boilers have a nest or nests of horizontal tubes so that there is direct tension on the tube plates due to the vertical load on the boiler ends or to their acting as horizontal ties across the shell, the thickness of the tube plates and the spacing of the tubes are to be such that the section of metal taking the load is sufficient to keep the stress within that allowed on the shell plates.

902 Each alternate tube in the outer vertical rows of tubes is to be a stay tube. The tube plates between the stay tubes are to be in accordance with J 712 and in addition:—

$$WP = \frac{(t - 1{,}6) \times S \times (p - d) \times 100}{2{,}03 \times D \times p}$$

where WP = working pressure, in kg. per cm.^{2},
S = minimum tensile strength of the steel plate, in kg. per mm.^{2},
t = thickness of the tube plate, in millimetres,
D = twice the radial distance of the centre of the outer row of tube holes from the axis of the shell, in millimetres,
p = vertical pitch of tubes, in millimetres,
d = diameter of the tube holes, in millimetres.

The least working pressure obtained by the above formula and that in J 712 is to be taken.

Section 10

GIRDERS

1001 For girders supporting the tops of combustion chambers the following formula is to be used:—

$$WP = \frac{C \times d^2 \times t}{(L - P) \times D \times L} \times \frac{S}{44}$$

where WP = working pressure, in kg. per cm.^{2},
d = depth of the girder at centre, in millimetres,
t = thickness of the girder at centre, where this is a forging, or the sum of the thicknesses of the plates where the girder is made of two plates, measured in millimetres,
L = length of the girder, in millimetres, measured between the tube plate and back chamber plate inside, or between tube plates in chambers common to two opposite furnaces,
P = pitch of stays supported by the girder, in millimetres,
D = distance apart of the girders, centre to centre, in millimetres,
S = minimum tensile strength of the material forming the girder, in kg. per mm.^{2},

$$C = \frac{n}{n+1} \times 1100,$$ where the number of stays (n) in each girder is odd,

$$\frac{n+1}{n+2} \times 1100,$$ where the number of stays (n) in each girder is even.

Section 11

STAYS

Screw Stays

1101 For steel screw stays with threads not coarser than 9 threads per 25,4 mm., the following formula is to be used, but in no case is the stress to exceed 6,33 kg. per mm.^{2}:—

$$WP = \frac{(d - 6{,}8)^2 \times 580}{a}$$

where WP = working pressure, in kg. per cm.^{2},
d = diameter of the stay over the thread, in millimetres,
a = area, in square millimetres, supported by one stay.

Longitudinal Stays

1102 For steel longitudinal stays with threads not coarser than 6 threads per 25,4 mm. the working pressure is to be calculated from the following formula, but in no case is the stress to exceed

$$\frac{\text{Minimum Tensile Strength, in kg. per mm.}^2}{5{,}7}$$

$$WP = \frac{(d - 8{,}6)^2 \times 670}{a} \times \frac{S}{44}$$

where WP = working pressure, in kg. per cm.^{2},
d = diameter of the stay over the thread, in millimetres,
a = area, in square millimetres, supported by one stay,
S = minimum tensile strength of the steel, in kg. per mm.2

1103 In cases where longitudinal stays are made with enlarged ends and the body of the stay is smaller in diameter than at the bottom of the thread, and in cases where coarser threads than 6 per 25,4 mm. are used, the working pressure is to be calculated from the following formula:—

$$WP = \frac{(d^1 - 3{,}2)^2 \times 670}{a} \times \frac{S}{44}$$

d^1 = diameter of the stay at the bottom of the thread or at the smallest part of the body.

Other symbols as defined in 1102.

Cross-reference

1104 *See* also requirements of J 108 to J 112.

Section 12

BOILER TUBES, PLAIN AND STAY, AND SUPERHEATER TUBES

1201 Where tubes are made of steel, the material is to comply with the relevant requirements of P 9.

1202 The following table gives the working pressures permissible with plain boiler tubes of standard thicknesses, whether of lapwelded wrought iron or of lapwelded or seamless mild steel:—

Outside diameter of tube in millimetres	Standard thicknesses in millimetres				Working pressures in kg. per cm.^{2}			
	A	B	C	D	A	B	C	D
51		3,00	3,25	3,65		11	15	21
57	3,00	3,25	3,65	4,00	10	13,5	18	23
63,5	3,00	3,25	3,65	4,00	9	12,5	16	21
70	3,00	3,25	3,65	4,00	8	11	15	19,5
76	3,25	3,65	4,00	4,5	10	13,5	17,5	21
82,5	3,25	3,65	4,00	4,5	9	12,5	16	19,5
89	3,25	3,65	4,00	4,5	8,5	11,5	15	18

1203 On stay tubes, whether of wrought iron or of steel, a working stress of 5,27 kg. per mm^2. of the net sectional area at the bottom of the thread is allowed.

1204 The minimum thickness of stay tubes measured under the threads is to be 6 mm. for marginal stay tubes and 5 mm. for other stay tubes.

1205 Stay tubes are to be screwed at both ends with continuous threads, and the holes in the tube plates are to be tapped with continuous threads. The pitch of the thread is to be not finer than 10 threads per 25,4 mm. It is desirable however that they should be screwed to the standard 9 threads per 25,4 mm. The stay tubes are to be expanded by roller expanders and not made tight by caulking only.

1206 Nuts are not to be fitted to stay tubes at the combustion chamber end.

1207 If stay tubes are increased in thickness at the screwed ends so that the thickness at the bottom of thread is practically the same as in the body of the tube, the thickening is to be attained by upsetting and not by any welding process, and the tubes are to be annealed after the upsetting.

Tubes for Superheaters attached to Cylindrical Boilers

1208 The minimum thickness of the tubes is to be calculated by the following formula:—

$$t = \frac{WP \times d}{530} + 1{,}8$$

where WP = working pressure in the boiler, kg. per cm.^{2}
d = external diameter, in millimetres.
t = thickness, in millimetres.

Section 13

DISHED END PLATES WITHOUT STAYS

1301 For ends of boiler drums and receivers, crowns of vertical boilers and other similar plates dished to partially spherical form subject to pressure on the concave side, but not exposed to flame, and having no unreinforced opening greater than four times the thickness of the plate, the working pressure to be allowed is to be determined by the following formula or, if desired, by the formula in J 1605 :—

$$WP = \frac{21{,}4 \times S\,(T - 0{,}8)}{R}$$

where WP = working pressure, in kg. per cm.^{2}
T = thickness of the end, in millimetres, after dishing but in no case to be less than the thickness of a seamless unpierced shell of the same diameter and material.
S = minimum tensile strength of the material, in kg. per mm.^{2}
R = inside radius of curvature of end, in millimetres, which is not to exceed the outside diameter of drum end.

The inside corner radius is to be not less than four times the thickness of the end plate and in no case less than 64 mm.

1302 Proposals to make dished end plates of semi-elliptic form will be considered provided full details are submitted before the work is commenced.

1303 Where the end is provided with a flanged manhole the thickness of the end in millimetres obtained by the formulæ in 1301 is to be increased by 3 mm. and the depth (F) of the manhole flange, measured in millimetres from the outer surface at the minor axis is to be not less than

$$F = \sqrt{T_1 \times W}$$

where T_1 = required thickness of the end plate, in millimetres,
W = minor axis of the manhole, in millimetres.

1304 Where the end is provided with large openings for branches, mountings, or unflanged manholes the thickness of the end, as determined by the formulæ in 1301, is to be increased by 3 mm. and adequate compensation is to be provided, at least equivalent to the cross sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

1305 Where the end is provided with small openings greater than four times the thickness of the end plate, local compensation is to be provided.

1306 Where the end or crown is a complete hemisphere without stays or other supports, and is made in more than one plate, the working pressure to be allowed is given by the following formula:—

$$WP = \frac{(t - 1{,}6)\,S \times J}{C \times R}$$

where WP = working pressure, in kg. per cm.^{2},
t = thickness of the plates, in millimetres,
S = minimum tensile strength of the steel plates, in kg. per mm.^{2},
J = strength of riveted joint as a percentage of the solid plate,
R = inner radius of curvature, in millimetres
C = 1,98 for treble riveted,
2,03 for double riveted,
2,31 for single riveted.

WATER TUBE BOILERS

Section 14

GENERAL REQUIREMENTS

1401 In the design and construction of water tube boilers intended for working pressures up to 105 kg. per cm.^{2} the following conditions are to be observed.

Materials

1402 The materials are to comply with the relevant requirements of Chapter P.

Where it is proposed to use alloy steels for superheater headers or tubes, particulars of the appropriate British or other national standard material specifications with details of the chemical compositions, heat treatment and mechanical properties are to be submitted for consideration.

1403 Where the material does not conform to an established standard, particulars of the long-term creep and rupture data at the operating temperature are to be submitted in addition to the details required by 1402 for the purpose of assessing a safe working stress.

If the long-term creep data has been estimated, details of the method of estimation are also to be submitted.

Particulars of scaling and corrosion resistance of the material under the operating conditions are to be submitted when required.

Protection of Drums and Headers

1404 Where any parts of the boiler drums or headers are not protected by tubes and are exposed to radiation from the fire, or to the impact of hot gases, they are to be protected by a shield of good refractory materials or by other approved means.

Access Arrangements

1405 Manholes are to be provided in all drums of sufficient size to permit of access for internal examination and cleaning and for fitting and expanding the tubes. In the case of headers for water walls, superheaters or economisers and of drums which are too small to permit entry, sight holes or mudholes sufficiently large and numerous for these purposes are to be provided.

1406 Doors for manholes, mudholes and sight holes are to be formed from steel plate or of other approved construction and all jointing surfaces are to be machined.

The doors are to be of the internal type and are to be provided with spigots which have a clearance of not more than 1,5 mm. all round, i.e. the axes of the opening are not to exceed those of the door by more than 3 mm.

1407 Doors for openings not larger than 230 mm. × 180 mm. need only be fitted with one stud which may be forged integral with the door. Larger doors are to be provided with two studs screwed through the door and fitted with nuts on the inside or alternatively, bolts may be used screwed through the door with the heads inside ; other methods of attachment may be accepted provided details are submitted for consideration.

The crossbars or dogs are to be of steel.

For smaller circular openings in headers and similar fittings an approved type of plug may be used.

Section 15

CONSTRUCTION OF WATER TUBE BOILERS

Seamless Drums

1501 Seamless forged drums are to be made in accordance with the requirements of P 7.

Welded and Riveted Drums

1502 Drums of welded construction are to be made in accordance with the requirements of J 18 to J 23 in so far as they are applicable.

1503 Drums of riveted construction are to be made in accordance with the requirements of J 5, which requires that the longitudinal seams are to be butt jointed with double butt straps.

1504 Drum shell plates are to be of cylindrical form and are to be bent entirely by machine ; local heating and hammering is not to be employed. Where the plate is bent cold to an internal radius of less than 20 times the plate thickness it is to be efficiently heat treated after bending. Drum ends are to be made from one piece of rolled plate.

1505 All steel plates which are dished, flanged or locally heated are afterwards to be annealed or normalised.

For heat treatment of welded pressure vessels, *see* J 1925 to J 1929. For plates which are hot formed, *see* P 310.

Thinning of Plates

1506 Where the tube plate is thicker than the drum shell plate, the tube plate, in way of the longitudinal and circumferential seams, is to be reduced in thickness by an equal amount on each side of the plate to the same thickness as the shell plate. This reduction in thickness is to be gradual and carried out by machining.

The thinning of dished end plates in way of butt welded joints is also to be carried out by machining but may be made from one side of the plate.

Tube Holes

1507 The tube holes in drums or headers are to be formed in such a way that the tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plates, there is to be a neck or belt of parallel

seating of at least 13 mm. in depth measured in a plane through the axis of the tube at the holes. Where the tubes are practically normal to their plates, this parallel seating is to be not less than 9,5 mm. in depth.

Tube Ends

1508 Tubes are to be carefully fitted in the tube holes and secured by means of expanding and belling or by other approved methods. Tubes are to project through the neck or belt of parallel seating by at least 6 mm. and where they are secured from drawing out by means of bellmouthing only the included angle of belling is to be not less than 30°.

Hydraulic Tests

1509 In all new boilers working at pressures up to 7 kg. per cm.^{2} the hydraulic test is to be twice the approved boiler pressure. For boilers working at pressures greater than 7 kg. per cm.^{2} the hydraulic test pressure is to be 1,5 times the approved boiler pressure plus 3,5 kg. per cm.^{2}

1510 All boiler mountings are to be subjected to a hydraulic test of twice the approved boiler pressure with the exception of feed check valves and other mountings connected to the main feed system which are to be tested to 2,5 times the approved boiler pressure, or twice the maximum pressure which can be developed in the feed line in normal service, whichever is the greater.

Section 16

SCANTLINGS OF DRUMS, ENDS, HEADERS AND TUBES

Cylindrical Shells

1601 When plans of water tube boilers are submitted for approval particulars of the safety valves and their disposition on boiler and superheater, together with the estimated pressure drop through the superheater, are to be stated. The pressures proposed for the settings of boiler and superheater safety valves are to be indicated on the boiler plan.

1602 The thickness of drum shell plates, which are unpierced by tube holes, is to be determined by formula 1. Where, however, the thickness obtained by that formula exceeds 10 per cent of R then formula 2 is to be used. For shells with riveted joints *see* J 5.

$$(1) \qquad t = \frac{WP \times R \times 2}{C \times f} + 1{,}6$$

$$(2) \qquad t = \frac{WP \times R \times 2}{C \times f - WP} + 1{,}6$$

where t = thickness of plate, in millimetres,

WP = maximum working pressure, in kg. per cm.^{2}

R = internal radius of the shell, in millimetres,

C is a coefficient having a value of

2 for seamless shells,

1,9 for fusion welded joints and

1,6 for forge welded joints.

f = nominal stress, in kg. per cm.^{2}

For shells of boiler steam and water drums f is to be taken as 0,27 of the specified minimum tensile strength of the material.

For seamless superheater drums and headers with metal temperatures above 316° C., the nominal stress f is to be taken from Table 1 which gives values for a number of wrought steels of approved composition in common use. Values of f for other steels will receive special consideration, *see* J 1403. When evaluating the stress f, the metal temperature is to be taken as not less than the maximum steam temperature plus 28° C. unless the headers are situated outside the boiler casing.

TABLE 1

MATERIAL		NOMINAL STRESS IN Kg. PER Cm.^{2} AT FOLLOWING METAL TEMPERATURES IN °C.								
TYPE OF STEEL	Minimum tensile strength Kg. per mm.^{2}	343	371	399	427	454	482	510	538	566
Carbon and Carbon-Manganese	**38**	940	930	845	740	560	420	—	—	—
	44	1100	1070	940	795	605	420	—	—	—
	50,5	1260	1210	1040	850	650	420	—	—	—
	57	1420	1350	1140	910	675	420	—	—	—
½% Mo.	**41**	1025	1025	1025	1000	940	775	460	—	—
	49	1225	1225	1225	1165	1085	845	460	—	—
1% Cr., ½% Mo.	**42,5**	1060	1060	1060	1040	970	810	550	335	195
	49	1225	1225	1225	1180	1095	880	560	335	195
2¼% Cr. 1% Mo.	**42,5**	1060	1060	1060	1040	970	810	550	420	325

The temperature limitations indicated in Table 1 are maxima for the types of steel listed but are not necessarily acceptable for all steels of these types.

Tube Plates

1603 The thickness of drum tube plates and cylindrical headers which are drilled for tubes is to be determined by the following formula :—

$$t = \frac{WP \times R \times 2}{1{,}8 \times f \times E - WP} + 1{,}6$$

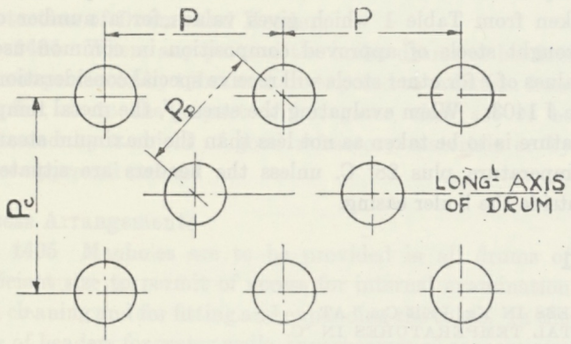
where t, WP and f are as defined in 1602,

R = internal radius of tube plate, in millimetres,

E = efficiency of ligaments between tube holes expressed as a fraction and calculated in accordance with 1604.

Ligament Efficiency

1604 Where tube plates or header shells are drilled for tubes the ligament efficiency between tube holes shall be determined by the following methods and the lowest value obtained shall be used in the formula of 1603 for tube plate thickness. Method 2 is only applicable where the tube holes are arranged in lines parallel to the axis so as to form a staggered arrangement with diagonal ligaments.



(1) $$E = \frac{P - d}{P}$$

(2) $$E = \frac{3{,}84 P_D (P_D - 0{,}95d)^2}{(P^2 + 0{,}5 P_C^2)(P_D - 0{,}95d) + P \times P_C \times 0{,}375d}$$

where E = ligament efficiency, expressed as a fraction,

P = longitudinal pitch of tube holes, in millimetres,

P_C = circumferential pitch of tube holes, in millimetres, in line circumferentially measured at the mid-thickness of the plate,

P_D = diagonal pitch of tube holes, in millimetres, measured at the mid-thickness of the plate,

d = mean effective diameter of tube holes, in millimetres.

The circumferential pitch P_C is to be such that the circumferential ligament efficiency is equal to or greater than half the ligament efficiency on the longitudinal axis.

Dished End Plates

1605 Where drum ends for boilers and headers are dished from plates and are subject to pressure on the concave side they are to comply with the following :—

(*a*) For ends dished to partial spherical form the inside radius of dishing, R, is to be not greater than the outside diameter D.

The inside corner radius, r, is to be not less than four times the plate thickness and in no case less than 64 mm.

The corner radius at the manhole flange is to be not less than 25 mm.

(*b*) For ends having no unreinforced opening greater than four times the plate thickness, or 64 mm., whichever is less, the working pressure to be allowed is to be determined by the following formula:—

$$WP = \frac{(T - 0{,}8) \times f \times h \times 8{,}4}{D^2} \times \left\{ \frac{\frac{r}{R} + 0{,}05}{\frac{r}{R} + 0{,}15} \right\}$$

where WP = working pressure, in kg. per cm.^{2},

T = thickness of the end, in millimetres, after dishing which in no case is to be less than the thickness of an unpierced shell of the same diameter and material,

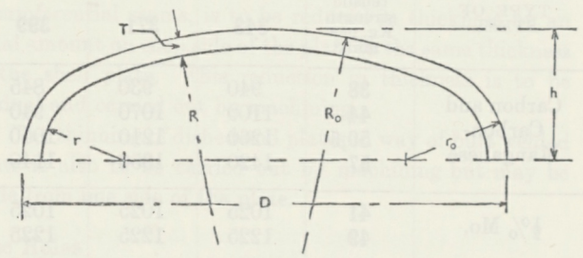
f = nominal stress, in kg. per cm.2, having values as stated in 1602,

D = outside diameter of end, in millimetres,

R = inside radius of dishing, in millimetres,

r = inside radius of corner, in millimetres,

h = external height of dishing, in millimetres measured from the centre of the corner radius, which is to be calculated as follows :—



$$h = R_o - \sqrt{\left(R_o - \frac{D}{2}\right)\left(R_o + \frac{D}{2} - 2r_o\right)}$$

R_o = outside radius of dishing, in millimetres,

r_o = outside radius of corner, in millimetres.

1606 Proposals to make dished ends of semi-ellipsoidal form will be considered provided details are submitted before the work is commenced.

Flat End Plates

1607 For unstayed flat end plates attached by one of the methods shown in J 18, Fig. 2 the working pressure is to be determined by the following formula :—

$$WP = \frac{(T-0{,}8)^2 \times f \times 7}{D^2}$$

where WP = working pressure, in kg. per cm.^{2},
T = thickness of plate, in millimetres,
f = nominal stress, in kg. per. cm.^{2}, having values as stated in 1602,
D = inside diameter, in millimetres.

Compensation for Openings

1608 Where a dished end is provided with large openings for branches, mountings or unflanged manholes, the thickness of the end as determined by the formula in 1605 is to be increased by 3 mm. and adequate compensation is to be provided at least equivalent to the cross-sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

1609 Where a dished end is provided with a flanged manhole the thickness of the end obtained by the formula in 1605 is to be increased by at least 15% but in no case less than 3 mm. and the depth of the manhole flange is to be determined as follows :—

$$F = \sqrt{T_1 \times W}$$

where F = depth of manhole flange, in millimetres, measured from the outer surface at the minor axis,
T_1 = required thickness of end plate, in millimetres,
W = minor axis of manhole, in millimetres.

1610 In the case of flat plates, the depth of the manhole flange measured from the outer surface is to be not less than $\sqrt{T \times W}$, where T is the thickness of the plate in millimetres and W is the minor axis of the hole in millimetres.

1611 Manholes in cylindrical shells are to have their shorter axes arranged longitudinally, and are to be located clear of the welded joints in the shell. Where the cylindrical shell is cut for a manhole, compensation is to be provided in accordance with 1612.

1612 Compensation is to be provided for all openings in shell plates if the diameters of such openings exceed 2,5 times the thickness of the shell plus 70 mm. or $\frac{D}{6}$ whichever is less, where D is the internal diameter of the cylindrical shell in millimetres.

The compensation provided is to be sufficient to ensure that the strength in way of the opening is not less than that of a seamless shell. For thickness of seamless shells *see* formula of 1602.

The width of reinforcing rings allowable for compensation is to be taken as $\sqrt{D \times T}$ or $\frac{D}{2}$ whichever is less, where D is the diameter of the opening in millimetres and T is the shell plate thickness in millimetres. If the surplus thickness of shell plate above that required for a seamless shell is included as compensation, the width allowable for this purpose is the same as that for compensating rings.

Where standpipes are welded to the shell the surplus thickness of the standpipe above that required to withstand the internal pressure may be included as compensation for a distance of $\sqrt{d \times t}$ from the plate surfaces where d and t in millimetres are the internal diameter and wall thickness of the standpipe respectively. The surplus thickness is to be taken as the difference in thickness proposed for the standpipes and that required by E 512 for a steampipe of the same bore and material.

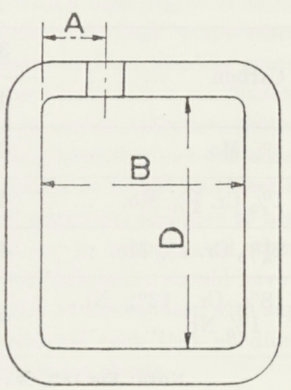
The sectional area of welds which attach compensating rings and standpipes to cylindrical shells may be included as compensation.

Headers of Rectangular Section

1613 The working pressure to be allowed for solid drawn and forged headers of rectangular section is to be determined by the following formulæ (1) and (2) whichever gives the lower pressure :—

(1) $$WP = \frac{4 \times f}{\left(\frac{B}{t}\right)^2 + \frac{D}{t}}$$

(2) $$WP = \frac{2 \times f \times E}{K \times \left(\frac{B}{t}\right)^2 + \frac{D}{2 \times t}}$$



where WP = maximum working pressure, in kg. per cm.^{2},

f = nominal stress, in kg. per cm.^{2}, having values as stated in 1602,

t = wall thickness, in millimetres, minus 1,5 mm.,

B = internal length, in millimetres, of the side under consideration,

D = internal length, in millimetres, of supporting side at right angles to dimension B,

E = minimum longitudinal efficiency of ligament between tube holes or hand holes, expressed as a fraction,

K is a coefficient having values dependent on the ratio of $\frac{A}{B}$ and is to be calculated as follows :—

$$K = 3\left[\frac{A}{B} - \left(\frac{A}{B}\right)^2 - \frac{1}{6}\right]$$

NOTE.—K as calculated may be $\pm$ but the numerical value only is to be taken for use in formula 2.

A = distance between centre line of tube holes or hand holes and the nearest supporting side, in millimetres ; where there are more than one row of tube holes in the length B, the value of A which gives a maximum K is to be selected.

Cross-reference

1614 For details of hand holes and doors, *see* J 1405 to J 1407.

For details of tube holes and fitting of tubes, *see* J 1507 and J 1508.

Tubes

1615 The minimum thickness of tubes is to be determined by the following formulæ :—

For all boiler and economiser tubes :

$$t = \frac{WP \times d}{44{,}5 \times S} + 0{,}015d + 1{,}0$$

For superheater tubes :

$$t = \frac{WP \times d}{K} + 1{,}5$$

where WP = working pressure in the boiler, in kg. per cm.^{2},

d = external diameter, in millimetres,

S = minimum tensile strength of the tube material, in kg. per mm.^{2},

t = thickness, in millimetres,

K is a coefficient given in Table 2.

The estimated metal temperature of the superheater tubes is to be stated when plans are submitted for approval but in no case is a temperature less than the maximum steam temperature plus 28° C. to be taken when evaluating K. For temperatures intermediate between those listed in the table and for carbon steels with tensile strengths intermediate between 32 and 44 kg. per mm.^{2}, the values of K may be obtained by interpolation.

TABLE 2

TUBE STEEL	Minimum tensile strength Kg. per mm.^{2}	SUPERHEATER TUBES—VALUE OF COEFFICIENT K AT FOLLOWING METAL TEMPERATURES IN °C.											
		343	371	399	427	454	482	510	538	566	593	621	649
Carbon	31,5	1410	1350	1270	1130	960	770	—	—	—	—	—	—
	44	1970	1830	1690	1410	1130	770	—	—	—	—	—	—
½% Mo.	39,5	1760	1760	1760	1760	1760	1550	1130	—	—	—	—	—
1% Cr. ½% Mo. ...	42,5	1900	1900	1900	1900	1900	1620	1410	980	630	—	—	—
2¼% Cr. 1% Mo. ...	42,5	1900	1900	1900	1900	1900	1760	1550	1270	980	—	—	—
18% Cr., 12% Ni., 1% Nb.	55	1970	1950	1940	1930	1910	1900	1880	1860	1830	1410	980	700

NOTE: For 18 % Cr., 12 % Ni., 1 % Nb. material, the Niobium content is not to be less than 10 times the Carbon content.

The thicknesses derived from these formulæ are minima and further provision is to be made for minus tolerances where necessary.

Where it is proposed to use other alloy steels for superheater tubes, particulars are to be submitted for special consideration in accordance with J 1402.

The formula for boiler tubes does not provide for adverse corrosion conditions and boiler tubes intended for low pressure boilers of 17,5 kg. per cm.^{2} working pressure and under with open feed systems are to be made 0,5 mm. thicker than required by the formula.

1616 The thickness of downcomer tubes and pipes which form an integral part of the boiler and which are not exposed to combustion gases is to comply with the Rules for steam pipes.

Standpipes

1617 Where standpipes and branches are attached to drums or headers by means of welding or by screwing and seal welding the minimum wall thickness for metal temperatures up to 343° C. is to be determined by the following formula but in no case is to be less than 6 mm.:—

$$t = \frac{D}{23} + 4{,}8$$

where t = thickness of standpipe or branch, in millimetres,
D = nominal bore, in millimetres.

For metal temperatures above 343° C., the wall thickness is to be not less than that required by the above formula or by the formula for shells in 1602, whichever is the greater.

1618 Every flange is to have a fillet with a radius not less than the thickness of the neck to which it is attached.

Section 17

BOILER MOUNTINGS AND FITTINGS FOR WATER TUBE BOILERS

Safety Valves

1701 Water tube boilers are to be fitted with not less than two safety valves of area and design in general accordance with the requirements of J 405 to J 409, except that the minimum diameter of high discharge type valves may be 25 mm. or equivalent free area.

Each saturated steam drum and each superheater are to be provided with at least one safety valve.

Where the superheater forms an integral part of the boiler the relieving capacity of the superheater safety valve(s), based on the reduced pressure at the superheater outlet, may be included as part of the total relieving capacity required for the boiler. As some National Authorities limit the proportion of the superheater safety valve relieving capacity which may be credited towards the total capacity required for the boiler, Builders should give attention to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

The boiler and superheater safety valves are to be so disposed and proportioned between saturated steam drum and superheater outlet that the superheater will be protected from overheating under all service conditions, including an emergency stop of the ship at full power.

Where it is proposed to fit full bore safety valves operated by independent pilot valves, the arrangements are to be submitted for consideration. The pipes connecting pilot valves and main valves are to be of ample bore and wall thickness to minimise the possibility of obstruction and damage.

Where it is impracticable to attach safety valves directly to the superheater the valves are to be located as near as possible thereto and fitted to a branch piece connected to the superheater outlet pipe.

In high temperature installations the drains from safety valves are to be led to a tank or other place where high temperature steam can be safely discharged.

Waste Steam Pipe

1702 The waste steam pipe and passages leading to it from the safety valves are to be in general accordance with the requirements of J 411.

In installations operating with a high degree of superheat, consideration is to be given to the high temperatures which waste steam pipes, silencers and surrounding spaces will attain when the superheater safety valves are blowing during accumulation tests and in service; adequate protection against heat effects is to be provided to the Surveyors satisfaction. Waste steam pipes are to be led well clear of electric cables and any parts or structures sensitive to heat or likely to distort; the pipes are to be insulated where necessary. In these installations each boiler should have a separate waste steam pipe system to atmosphere with supporting and expansion arrangements such that no direct loading is imposed on the safety valve chests.

Safety Valve Settings

1703 All boiler and superheater safety valves are to be set under steam to their respective working pressures which are to be not greater than 3 per cent above the pressure for which the boiler is approved. In the setting of superheater safety valves, allowance is to be made for the pressure drop through the superheater so that under discharge conditions the pressure in the boiler will not exceed the approved boiler pressure.

In no case shall the superheater safety valve setting exceed by more than 3 per cent the pressure for which the steam piping and shafting are approved.

Accumulation Tests

1704 Tests for accumulation of pressure are to be carried out with the stop valve closed and under full firing conditions for a period not exceeding 7 minutes. The accumulation is not to exceed 10 per cent of the working pressure.

Where accumulation tests might endanger the superheaters, consideration will be given in cases of oil-fired boilers to the omission of these tests, provided that application is made when the boiler plan and sizes of safety valves are submitted for approval, and that the safety valves are of an approved type for which the capacity has been established by test in the presence of the Surveyors or an approved independent authority, or for which the Society is satisfied, by long experience of accumulation tests, that the capacity is adequate.

When it is agreed to waive accumulation tests it will be required that the valve makers provide a certificate for each safety valve, stating its rated capacity at the approved working conditions of the boilers and that the boiler makers provide a certificate for each boiler stating its maximum evaporation.

The safety valves are to be found satisfactory in operation under working conditions during the trials of the machinery on board ship.

Stop Valves

1705 Where two or more boilers are connected together, stop valves of self-closing or non-return types are to be fitted.

Water Level Indicators

1706 Every boiler is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a glass water gauge.

The other means is to be either an additional glass water gauge or an approved equivalent device other than test cocks, but where a steam and water drum exceeding 3,96 metres in length is fitted athwartships, two glass water gauges are to be fitted in suitable positions, one near each end of the drum.

1707 The position of the glass water gauges of boilers in which the tubes are entirely drowned when cold is to be such that water is just showing in the glass when the water level in the steam drum is just above the top of the uppermost tubes when the boiler is cold. In boilers, the tubes of which are not entirely drowned when cold, the glass water gauges are to be placed, to the Surveyor's satisfaction, in the positions which have been found by experience to indicate satisfactorily that the water content is sufficient for safety when the boiler is worked under all service conditions.

Feed Check Valves and Water Level Regulators

1708 Two feed check valves, connected to separate feed lines, are to be provided for each boiler and are to be attached, wherever practicable, direct to the boiler or to an economiser which forms an integral part of the boiler.

Where, however, the arrangements necessitate the use of a common inlet pipe on the economiser for both main and auxiliary feed systems, this pipe is to be as short as practicable and the arrangement of check valves is to be such that either feed line can be effectively isolated without interruption of the feed water supply to the boiler.

At least one of the feed water systems is to be fitted with an approved feed water regulator whereby the water level in the boilers is controlled automatically. (*See* E 7 for arrangements and details of boiler feed systems.)

1709 The feed check valves are to be fitted with efficient gearing, whereby they can be satisfactorily worked from the stokehold floor, or other convenient position.

1710 Standpipes on boilers, for feed inlets, are to be designed with an internal pipe to prevent direct contact between the feed pipe and the boiler shell or end plates with the object of minimizing thermal stresses in these plates.

Similar arrangements are to be provided for desuperheater and other connections where significant temperature differences occur in service.

Mountings and Fittings

1711 Mountings and fittings not mentioned in this Section are to be in accordance with the requirements of J 4.

WELDED PRESSURE VESSELS

For list of manufacturers of Class 1 Welded Pressure Vessels see appendix to this Chapter.

Section 18

General

1801 The requirements of Sections 18 to 24, except where otherwise stated, are applicable to boilers, air receivers, heat exchangers and other pressure vessels of fusion welded construction intended for marine services, but excluding vessels containing radioactive materials or gases.

1802 The term "fusion weld" is, for the purpose of these requirements, applicable to welded joints made by the metal arc process with covered electrodes or other electric arc process in which the arc stream and the deposited metal are shielded from atmospheric contamination. The welding may be done by hand or by machine.

Materials

1803 Materials used in the construction of welded pressure vessels are to be of weldable quality steel and are to be manufactured and tested in accordance with the relevant requirements of Chapter P.

The tensile strengths of mild steel pipes, forgings and castings are not to exceed 55 kg. per mm.^{2} The tensile strengths of carbon and carbon-manganese steel plates are to be within the range of 38 to 60 kg. per mm.^{2} subject to the limitation of application of P 307.

1804 Where it is proposed to use alloy or other steels not covered in Chapter P, specifications detailing the mechanical properties, chemical composition and heat treatment are to be submitted for special consideration. As the strengths of such steels are sensitive to heat treatment, check tensile tests after hot forming, normalising, and stress relieving at the fabrication works will, in general, be required.

1805 All steels for Class 1 vessels are to be killed (*see* P 307); steels for Classes 2 and 3 vessels may be killed or semi-killed. All these steels are to contain not more than 0,05 per cent sulphur and 0,05 per cent phosphorus.

Plans

1806 Plans in triplicate, showing full constructional features of the vessel and dimensional details of the weld grooves for longitudinal and circumferential seams and attachments, together with particulars of the electrodes and of the mechanical properties of the materials are to be submitted before construction is commenced.

Electrodes

1807 Where a pressure vessel is to be made of alloy steel and where the scantlings have been approved on the basis of the high temperature properties of the material, particulars of the electrodes to be used including typical mechanical properties and chemical composition of the deposited weld metal are to be submitted for approval.

Particulars of typical creep, rupture and ductility properties of the deposited weld metal at elevated temperatures are also to be submitted when required.

Classification of Fusion Welded Pressure Vessels

1808 For Rule purposes pressure vessels are graded as follows:—

CLASS 1

Pressure parts of boilers and fired pressure vessels intended for working pressures above 3,5 kg. per cm.^{2} Pressure parts of steam heated steam generators where the working pressure exceeds 11,5 kg. per cm.^{2}, or where the working pressure in kg. per cm.^{2} multiplied by the internal diameter of the shell in mm. exceeds 14700.

Other pressure vessels where the shell thickness exceeds 38 mm.

CLASS 2

Pressure parts of boilers and fired pressure vessels not included in Class 1.

Pressure parts of steam heated steam generators not included in Class 1.

Other pressure vessels where the working pressure exceeds 17,5 kg. per cm.^{2}, or the metal temperature exceeds 149° C., or where the working pressure in kg. per cm.^{2} multiplied by the actual thickness of the shell in mm. exceeds 160.

Maximum shell thickness 38 mm.

CLASS 3

Vessels not included in Classes 1 and 2.

Maximum shell thickness 16 mm.

1809 In special circumstances relating to service conditions, materials, operating temperature, the carriage of dangerous gases and liquids, etc., it may be necessary to include other pressure vessels in the Class 1 category.

1810 All Class 1 vessels are required to be heat treated. Certain Class 2 vessels, as described in the following paragraph, are required to be heat treated and are graded as Class 2A. Other Class 2 vessels, graded as Class 2B, and all Class 3 vessels are not required to be heat treated.

Pressure parts of boilers, fired pressure vessels and steam heated steam generators in Class 2 category are required to be heat treated. Other vessels in Class 2 are required to be heat treated where the shell thickness in mm. exceeds $\frac{D}{130} + 10$ or 32 mm. whichever is the smaller where D=internal diameter of vessel in mm.

For heat treatment of pressure vessels *see* J 1925 to J 1929.

1811 Vessels which are required to comply with Classes 2 or 3 standards will, if manufactured in accordance with the requirements for a superior class, be approved with the scantlings appropriate to that class.

1812 The conditions of manufacture and test for the three classes are given in the following Table 3.

TABLE 3

Class	Radiographic examination	Heat Treatment	Routine Weld Tests	Hydraulic Tests
1	required	required	required	required
2A	—	required	required	required
2B	—	—	required	required
3	—	—	—	required

Scantlings of Welded Pressure Vessels

1813 For the scantlings of shell and ends of cylindrical boilers, water tube boilers and steam heated steam generators *see* J 16 and for air receiver ends *see also* J 24.

For the scantlings of shells and ends of other welded pressure vessels, *see* 1815 and 1816.

Joints

1814 Longitudinal joints for all classes of vessels are to be butt joints. Circumferential joints for Class 1 vessels are to be butt joints and for Classes 2 and 3 vessels may be either butt joints or lap joints.

Shells of Cylindrical and Spherical Vessels

1815 The thickness of shell plates is to be determined by the following formula but in no case is to be less than 5 mm.

$$WP = \frac{C \times f \times (T - 1{,}6)}{d} \qquad T = \frac{WP \times d}{C \times f} + 1{,}6$$

where WP = maximum working pressure in kg. per cm.^{2},
T = thickness of shell plate in millimetres,
f = nominal stress in kg. per cm.^{2},
d = internal diameter of the shell in millimetres,
C = coefficient from the following table.

Vessel Grade	Coefficient C	
	Cylindrical Vessels	Spherical Vessels
Seamless	2	—
Welded Class 1	1,9	3,8
Welded Class 2A	1,6	3,2
Welded Class 2B	1,5	3,0
Welded Class 3	1,05	—

For pressure vessels with working metal temperatures of 316° C. and under f is to be taken as 1/3,5 of the specified minimum tensile strength of the material and for those operating at metal temperatures above 316° C. the nominal stresses at temperatures given in Table 1, J 1602, are to be used. For pressure vessels intended for the carriage of liquefied petroleum gases *see also* J 25.

Dished End Plates

1816 Ends dished to partial spherical form and subject to pressure on the concave side, are to comply with the following requirements:—

(a) The inside radius of dishing R is not to be greater than the outside diameter D of the end.

(b) The inside corner radius r is not to be less than four times the thickness of the end or 10 per cent of the inside diameter whichever is greater.

(c) The permissible working pressure is to be determined by the following formula:—

$$WP = \frac{8{,}4\,(T - 0{,}8) \times f \times h \times J}{D^2} \times \left\{ \frac{\frac{r}{R} + 0{,}05}{\frac{r}{R} + 0{,}15} \right\}$$

where WP = maximum working pressure in kg. per cm^2.,
T = thickness of end in millimetres after dishing. Where ends are made from one plate the thickness is to be not less than that of a seamless shell of the same diameter and material,

f = nominal stress in kg. per cm.^{2} having values as stated in 1815,

J = 1,00 for ends made from one plate
0,95 for ends made from two or more plates with Class 1 welded seams
0,80 for ends made from two or more plates with Class 2A welded seams
0,75 for ends made from two or more plates with Class 2B welded seams,

D = outside diameter of end in millimetres,

R = inside radius of dishing in millimetres,

r = inside radius of corner in millimetres,

h = external height of dishing, in millimetres, measured from centre of corner radius which is to be calculated as follows:—

$$h = R_o - \sqrt{\left(R_o - \frac{D}{2}\right)\left(R_o + \frac{D}{2} - 2r_o\right)}$$

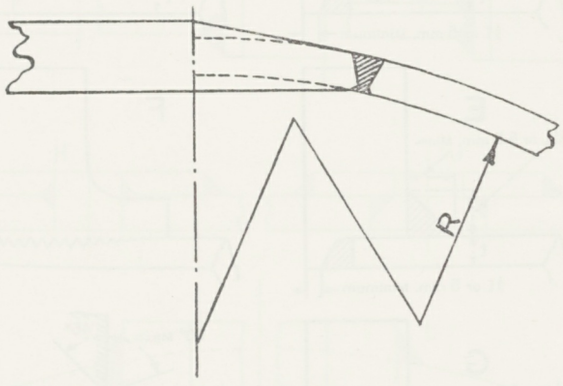
R_o = outside radius or dishing in millimetres,

r_o = outside corner radius in millimetres.

Hemispherical End Plates

1817 The thickness of hemispherical ends made from one or more plates is to be determined by the formula in 1815 with the value of coefficient C corresponding to the appropriate class of welded pressure vessel.

Where hemispherical ends are butt welded to cylindrical shells the thickness of the shell is to be reduced by taper to that of the end and the centre of the hemisphere is to be so located that the entire tapered portion of the shell and the butt weld are within the hemisphere (*see* sketch).



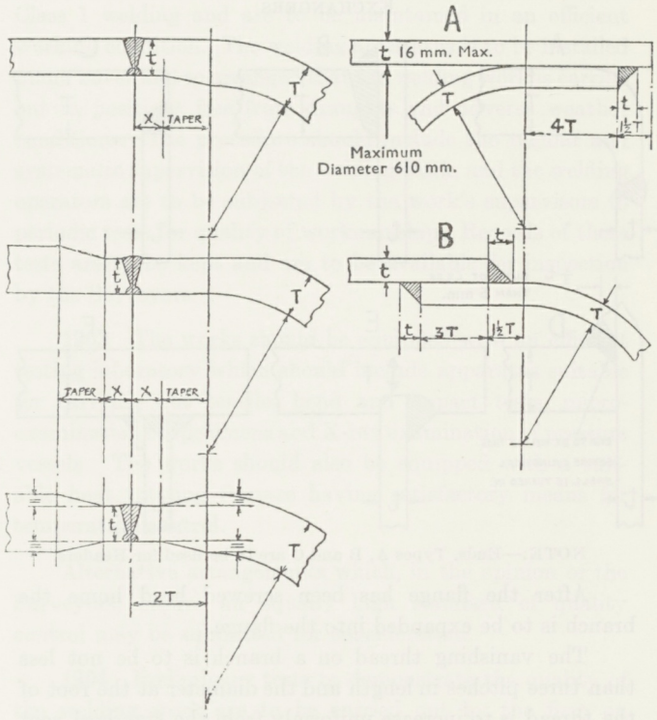
If the hemispherical end is provided with a parallel portion the thickness of this portion is to be not less than that of a seamless or welded shell, whichever is applicable, of the same diameter and material.

1818 The scantlings of dished ends for Class 3 pressure vessels subject to pressure on the convex side are to be determined by the formula in J 2404.

1819 For typical acceptable methods of attaching dished ends to cylindrical shells and for limitations of different types *see* Fig. 1. Types A and B are to be made a tight fit in the cylindrical shell. (*See* J 2206.)

Parallel portions marked x of about 32 mm. are to be provided for Class 1 pressure vessels to facilitate the radiographic examination of the welds. The thickness t of the parallel portions is to be not less than that of an unpierced cylindrical shell of seamless or welded construction, whichever is applicable. The taper on each side of the plates is to be not greater than 1 in 4.

FIG. 1 TYPICAL ACCEPTABLE METHODS OF ATTACHING DISHED END PLATES TO CYLINDRICAL SHELLS



Type	Acceptable for
A	Class 3 pressure vessels
B	Class 2 and 3 pressure vessels
Others	Class 1, 2 and 3 pressure vessels

Flat End Plates

1820 The scantlings of flat end plates for Classes 1, 2 and 3 pressure vessels are to be determined by the formula in J 1607.

1821 For typical acceptable methods of attaching flat ends to small cylindrical shells and for application of different types *see* Fig. 2.

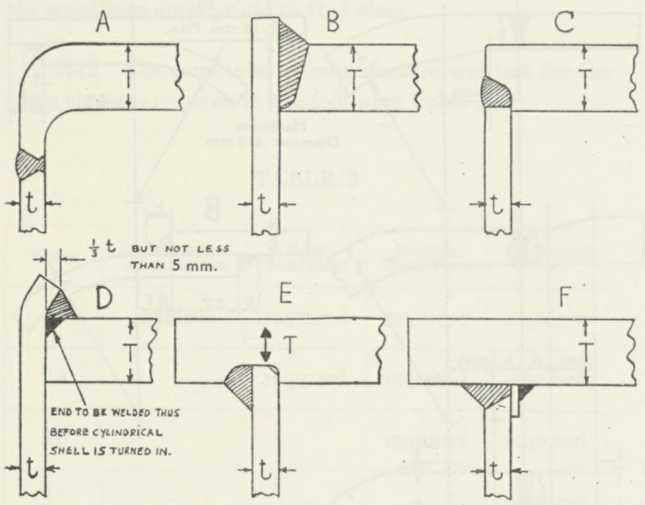
Standpipes

1822 The scantlings of standpipes are to be determined by the requirements of J 1617.

For acceptable methods of attaching flanges to standpipes and service limitations of the various types *see* Fig. 3.

Where flanges are secured by screwing, the branch and flange are to be screwed with a vanishing thread, and the diameter of the screwed portion of the branch over the thread is to be not less than the outside diameter of the unscrewed branch.

FIG. 2 TYPICAL ACCEPTABLE METHODS OF ATTACHING UNSTAYED FLAT END PLATES TO SMALL PRESSURE VESSELS, CIRCULAR AND SQUARE HEADERS AND HEAT EXCHANGERS



NOTE:—Ends, Types A, B and C are to be used for Headers.

After the flange has been screwed hard home the branch is to be expanded into the flange.

The vanishing thread on a branch is to be not less than three pitches in length and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

Welded Attachments to Pressure Vessels

1823 Doubling plates with well rounded corners are to be fitted in way of attachments such as lifting lugs, supporting brackets and feet to minimise load concentrations on pressure shells and ends. Compensating plates, pads, brackets and supporting feet are to be bedded closely to the surface before being welded and are to be provided with a "tell-tale" hole not greater than 9,5 mm. in diameter open to the atmosphere to provide for the release of entrapped air during heat treatment of the vessel or as a means of indicating any leakage during hydraulic testing and in service.

For acceptable methods of attaching standpipes, branches, compensating plates and pads *see* Fig. 4.

Alternative methods of attachment may be accepted provided details are submitted for consideration.

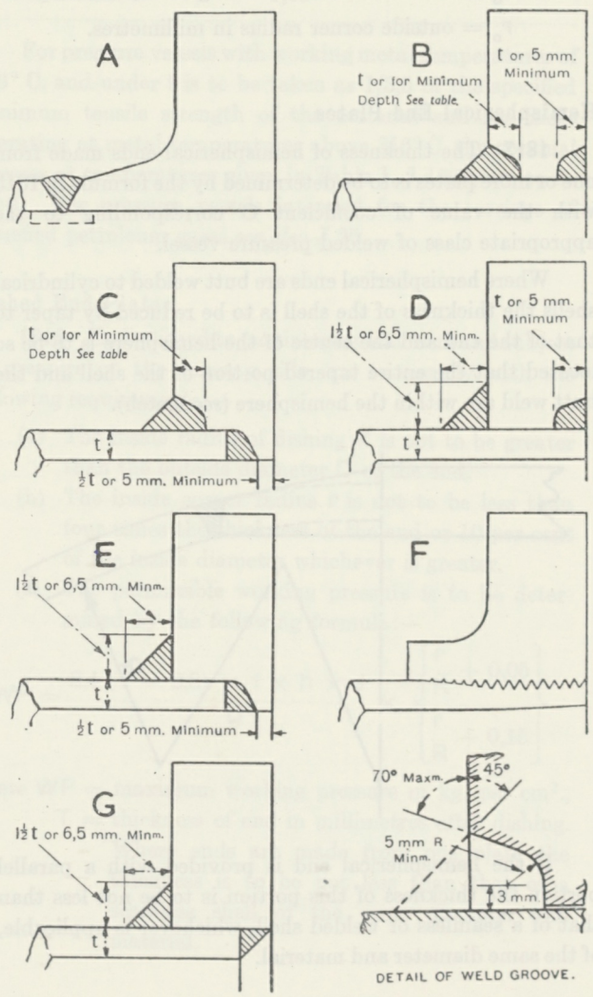
Access Arrangements

1824 Manhole, inspection and cleaning openings and doors for cylindrical boilers, watertube boilers and air receivers are to be in accordance with the relevant sections of this chapter.

Cross-reference

1825 For compensation for openings in shell and end plates, *see* J 1608 to J 1612.

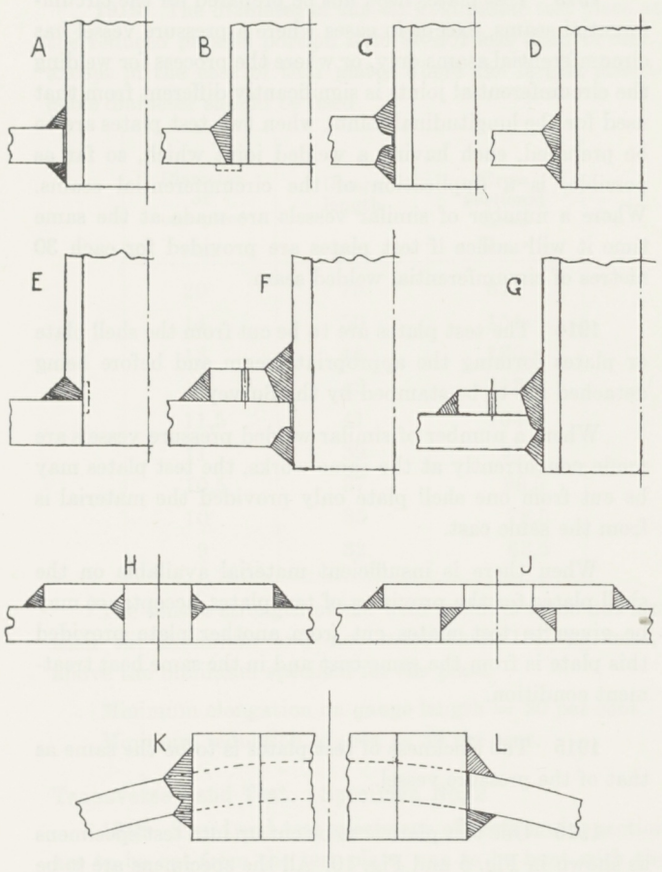
FIG. 3 ACCEPTABLE METHODS OF ATTACHING FLANGES TO STEEL BRANCHES OR STANDPIPES



Pipe Bore	Minimum Depth of Groove for flanges B and C
13mm. and 19mm.	6,5mm.
25mm. to 38mm.	8mm.
50mm. and over	9,5mm.

Type of Flange Attachment	Service and Rating			
	Feed, Air, Oil Fuel and other fluids		Steam	
	Pressure kg. per cm.²	Temperature °C.	Pressure kg. per cm.²	Temperature °C.
A	All Conditions		All Conditions	
B & C	All Conditions		52,5	454
D & E	52,5	260	38,5	399
F	42		31,5	
G	17,5		17,5	260

FIG. 4 TYPICAL ACCEPTABLE METHODS OF ATTACHING BRANCHES AND PADS



NOTE:—Types A and L attachments are not to be used for openings which require to be compensated. Backing Rings may be used with Types B and E.

Section 19

REQUIREMENTS FOR CLASS 1 FUSION WELDING

Preliminary Conditions and Tests

1901 Fusion welded pressure vessels constructed to Class 1 requirements will be accepted only if manufactured by firms equipped and competent to undertake high quality welding. In order that firms may be approved for this purpose, it will be necessary for the Surveyors to visit the firm's works for the purpose of inspecting the welding plant, equipment and procedure and to arrange for the carrying out of preliminary tests and the survey during construction and testing of a full size welded pressure vessel as stated in 1904, 1905 and 1906.

1902 The welding plant and equipment are to be suitable for undertaking work of the standard required for Class 1 welding and are to be maintained in an efficient working condition. The welding apparatus is to be installed under cover and so arranged that the welding work is carried out in positions free from draughts and adverse weather conditions. The procedure should include the regular and systematic supervision of the welding work, and the welding operators are to be subjected by the work's supervisors to periodic tests for quality of workmanship. Records of these tests are to be kept and are to be available for inspection by the Surveyors.

1903 The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, micro-examination of specimens and X-ray examination of pressure vessels. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control.

Alternative arrangements which, in the opinion of the Surveyors, ensure an equally high standard of quality control may be submitted for consideration.

1904 Preliminary tests to demonstrate the quality of the welding work are to be carried out by the firm on specimens cut from test plates welded under the supervision of the Surveyors. The test plates are to comply with 1907, but are to be at least 19 mm. thick. The welded seams of the test plates are to be radiographed. The Surveyors are to select portions of the test plates containing the welded joint from which specimens are to be provided for the following:—

(1) Tensile, bend, impact, hardness and fatigue tests.

(2) Micrographs at 100 and 300 magnifications, of weld centre, fusion zone and parent plate.

(3) Macrograph of full section of weld.

(4) Chemical analysis of deposited weld metal.

(5) Chemical analysis of test plates.

As an alternative to (5), a guaranteed analysis obtained from the steel makers will be accepted.

1905 Where the welding is carried out by an established and approved process, the fatigue tests and micrographs listed in 1904 will in general not be required.

1906 A full size pressure vessel is to be constructed in accordance with the requirements of these Rules for Class 1 fusion welded pressure vessels under the supervision of the Surveyors.

1907 The approval of works for the manufacture of Class 1 welded pressure vessels will be limited to the grade of vessel which has been the subject of test in obtaining approval. Grading will be governed by shell thickness at the welded joint and by the quality of the steel. For grading purposes steels will be grouped in three categories, namely, (1) carbon and carbon-manganese steels (38–54 kg. per mm.^{2}), Grades 1, 2, 3 and 4, (2) carbon and carbon-manganese steels (50–60 kg. per mm.^{2}) Grade 5, and (3) low alloy steels. For the foregoing reasons, therefore, the test plates and full size pressure vessel mentioned in paragraphs 1904, 1905 and 1906 are to be representative, as regards materials and approximate shell thickness, of the production vessels for which approval is desired.

1908 On completion of the inspection and tests, the Surveyor's report including the results of the preliminary tests and the tests of the full size pressure vessel is to be submitted for the consideration of the Committee. The report should also include the radiographs and particulars of any fusion welded pressure vessels previously constructed by the firm.

1909 If a firm intends to manufacture pressure vessels either of a different grade, or by means of a different welding process than used in the construction of the full size vessel on which the original approval of the works was based, a series of procedure tests may be required to cover the new conditions of manufacture. In the first instance, however, particulars and plans showing full details of the proposed vessel or new welding process are to be submitted, when the necessity for procedure tests will receive consideration.

1910 Where firms desire their name to be included in the Society's list of firms recognised by the Committee as experienced manufacturers of Class 1 fusion welded pressure vessels, they should make application at the initial stages of having their works approved.

Routine Tests for Class 1 Fusion Welded Pressure Vessels

1911 Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported, during welding, that warping is reduced to a minimum.

1912 The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

1913 Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, or where the process for welding the circumferential joints is significantly different from that used for the longitudinal joints, when two test plates are to be prepared, each having a welded joint which, so far as possible, is a duplication of the circumferential seams. Where a number of similar vessels are made at the same time it will suffice if test plates are provided for each 30 metres of circumferential welded seam.

1914 The test plates are to be cut from the shell plate or plates forming the appropriate seam and before being detached are to be stamped by the Surveyor.

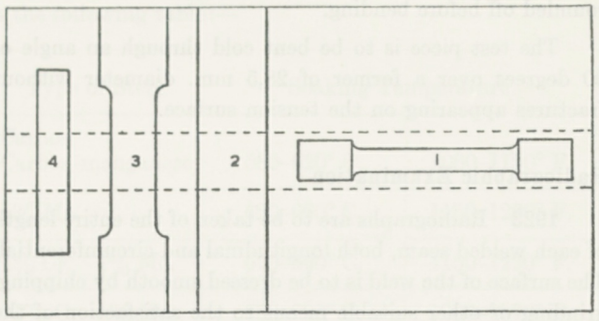
Where a number of similar welded pressure vessels are made concurrently at the same works, the test plates may be cut from one shell plate only provided the material is from the same cast.

When there is insufficient material available on the shell plates for the provision of test plates, acceptance may be given to test plates cut from another plate provided this plate is from the same cast and in the same heat treatment condition.

1915 The thickness of test plates is to be the same as that of the pressure vessel.

1916 One test plate is to be cut up into test specimens as shown in Fig. 5 and Fig. 10. All the specimens are to be cut from a plate of suitable length and are to comply with the test requirements detailed in 1918 to 1922.

FIG. 5



(1) Tensile, all weld metal. (3) Tensile (joint).

(2) Bend. (4) Macro.

Retests

1917 If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

Tensile Test for all Weld Metal. Specimen No. 1

1918 The diameter of the all weld metal test piece at the reduced parallel portion is to be not less than 14 mm., except in the case of thin plates where the largest practicable diameter should be used.

Diameter of test piece mm.	Gauge length mm.	Cross Sectional Area mm.²
20	75	314
14	50	154
13	46	133
12	43	113
11,5	41	104
11	39	95
10,5	37	86,5
10	35	78,5
9	32	63,5

The tensile strength of the weld metal is to be not less than the minimum and not more than 15,7 kg. mm.² above the minimum specified for the plate.

Minimum elongation on gauge length = 20 per cent.

Minimum reduction of area = 35 per cent.

Transverse Bend Test. Specimen No. 2

1919 Two bend test specimens of rectangular section are to be cut from the test plate, one to be bent with the outer surface of the weld in tension, and the other with the inner surface in tension.

The specimens are to be cut transversely to the weld and are to have a width equal to 1,5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. The edges may be rounded off to a radius not exceeding 10 per cent of the thickness of the specimen.

In plate thicknesses not exceeding 32 mm., the thickness of the specimens should be equal to the thickness of the test plate. Where the plate thickness exceeds 32 mm., the specimens should, in all cases, have a thickness of 32 mm., and width of 48 mm. These should be prepared by discarding metal from the surfaces of the specimens which will be in compression when the test is applied. *See* Figs. 6 and 7.

Where the thickness of the plate permits, the bend specimens may be prepared as shown in Fig. 8.

For each specimen the weld reinforcement should be removed by buffing or machining so that the outer and inner surfaces of the weld are flush with the surface of the plate.

Each specimen is to be bent cold without fracture through an angle of 180 degrees, over a former having diameter not greater than three times the thickness of the specimen. The distance between supports should be not more than 5,2 times the thickness of the specimen.

FIG. 6 NORMAL BEND SPECIMEN

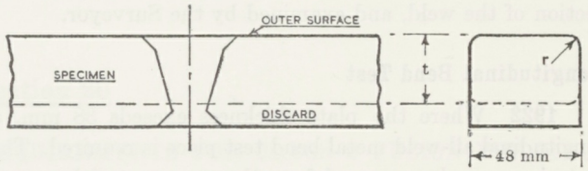


FIG. 7 REVERSE BEND SPECIMEN

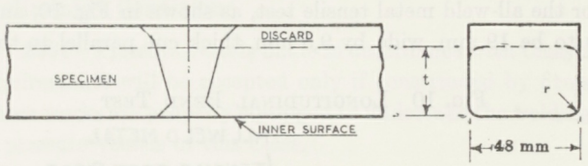
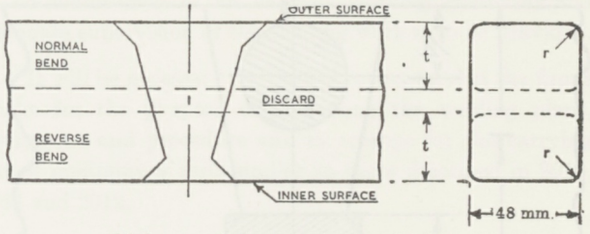


FIG. 8 NORMAL AND REVERSE BEND SPECIMENS CUT FROM SINGLE PIECE OF PLATE



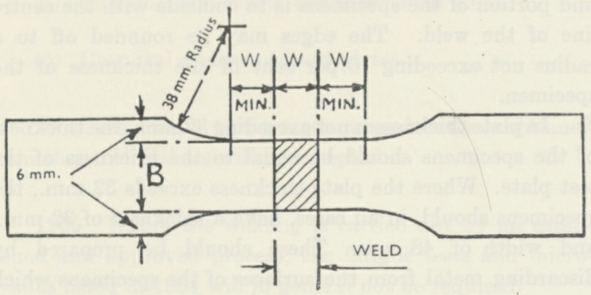
t = thickness of the specimen which is the thickness of the plate or 32 mm., whichever is the lesser.

r = corner radii not exceeding 0,1t

NOTE:—Where t is less than 32 mm. the width of the specimen is to be 1,5t.

Tensile Test for Joint. Specimen No. 3

1920 FIG. 9



B = Not less than thickness of plate with a minimum width of 38 mm.

An equivalent form of test piece to that shown in Fig. 9 may be accepted.

The weld is to be machined flush with plates on both sides.

The ultimate tensile strength is to be not less than the minimum specified for the plate. If the test piece breaks in the plate or fusion zone at not less than 95% of the minimum specified for the plate the test may be accepted.

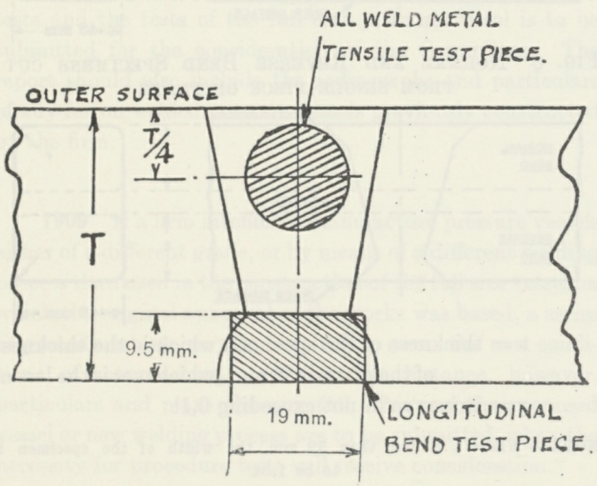
Macro Specimen. Specimen No. 4

1921 The specimen is to be etched across the full section of the weld, and examined by the Surveyor.

Longitudinal Bend Test

1922 Where the plate thickness exceeds 38 mm. a longitudinal all-weld metal bend test piece is required. The test piece may be prepared from the same material as used for the all-weld metal tensile test, as shown in Fig. 10, and is to be 19 mm. wide by 9,5 mm. thick cut parallel to the seam. The sharp edges of the test piece may be slightly rounded off before bending.

FIG. 10 LONGITUDINAL BEND TEST



The test piece is to be bent cold through an angle of 90 degrees over a former of 28,5 mm. diameter without fractures appearing on the tension surface.

Radiographic Examination

1923 Radiographs are to be taken of the entire length of each welded seam, both longitudinal and circumferential. The surface of the weld is to be dressed smooth by chipping, grinding or other suitable means to the satisfaction of the Surveyor. The radiographs are to be marked in such a way that the corresponding portions of the welded seams can be readily and accurately identified. The radiographs are to be examined by the Surveyor who will indicate whether any repairs are necessary. On completion of repairs the affected portions of the seams are to be re-radiographed.

Penetrameters of approved type are to be placed at each end of each radiograph. They are to be placed adjacent to the welded seam and on the surface facing the source of radiation. The X-ray technique employed is to be such that the thickness of the penetrameter corresponding to 2 per cent of the thickness of the parent plate will be clearly shown on the radiograph

The use of gamma rays may be permitted in exceptional circumstances, when details should be submitted for consideration.

Magnetic Crack Detection Examination

1924 Where vessels are made of carbon steel having a tensile strength exceeding 55 kg. per mm.^{2}, or of alloy steel, all welds attaching standpipes, compensating plates, etc., to the vessel, which cannot be radiographed, are to be examined by magnetic crack detection, or other approved non-destructive methods.

Heat Treatment

1925 Each pressure vessel is to be efficiently heat treated on completion of the welding of all joints and attachments to shell and ends, and before the hydraulic test is carried out.

Heat treatment is to be carried out in a properly constructed and temperature controlled furnace and is to consist of heating the vessel slowly and uniformly to a suitable stress relieving temperature, soaking for a suitable period, followed by uniform cooling to atmospheric temperature. The temperature and soaking periods are to be selected which will relieve residual stress without undue reduction of material tensile strength.

Recommended temperatures for stress relief are given in the following table:—

Type of Steel	Soaking Temperature	
Carbon Carbon-manganese	580–620° C.	1080–1150° F.
½% Mo.	620–660° C.	1150–1220° F.
1% Cr. ½% Mo.	620–660° C.	1150–1220° F.
2¼% Cr. 1% Mo.	650–690° C.	1200–1270° F.

Soaking periods for the materials listed in the above table are to be at least one hour per 25 mm. of plate thickness with a minimum period of one hour, except that for carbon and carbon manganese steels the period of soaking is to be increased by one hour, i.e. to one hour per 25 mm. of plate thickness plus one hour with a minimum period of two hours.

In cases where other materials are used for pressure vessel construction, full details of the proposed heat treatment are to be submitted for consideration.

1926 Where pressure vessels are of such dimensions that the whole length cannot be accommodated in the furnace at one time, the pressure vessels may be heated in sections provided sufficient overlap is allowed to ensure the heat treatment of the entire length of the longitudinal seam.

1927 Test plates should be heat treated in the same furnace and at the same time as the pressure vessels which they represent. In special cases, however, it may be permissible to heat treat the test plates separately from the pressure vessels provided the Surveyor is satisfied with the means adopted to ensure that the following factors will be the same for the pressure vessels as for their respective test plates:—

Rate of heating.

Maximum temperature.

Time held at maximum temperature.

Conditions of cooling.

1928 Where a number of test plates are heated together in a furnace, care is to be taken to ensure that each plate is uniformly exposed to the heat of the furnace.

1929 Where it is proposed to adopt special methods of heat treatment full particulars are to be submitted for consideration. In such cases it may be necessary to carry out tests to show the effect of the proposed heat treatment.

Hydraulic Test

1930 The hydraulic test pressure is to be 1,5 times the working pressure. (For steam and water drums of water tube boilers, *see* J 1509).

Where a vessel is designed for use at elevated temperatures a test pressure (TP) is to be applied, such that the vessel is subjected under hydraulic test to approximately the same wall stress as a vessel operating at a metal temperature below 343° C. as follows:—

$$TP = 1{,}5\ WP \times \frac{f \text{ at } 343^\circ \text{ C.}}{f \text{ at working temperature}}$$

where f is the nominal stress obtained from Table 1.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

This hammer test is not required for vessels where the longitudinal and circumferential seams have been radiographed.

Modification of Requirements

1931 In the case of firms of large experience some modification may be permitted in regard to the requirements of 1904 to 1906.

Section 20

REQUIREMENTS FOR CLASS 2 FUSION WELDING

Preliminary Conditions

2001 Pressure vessels made in accordance with Class 2 requirements will be accepted only if constructed by firms whose works are properly equipped to undertake the welding of pressure vessels of this Class.

The welding plant is to be installed under cover and is to be maintained in an efficient working condition and adequate supervision of the welding work is to be provided.

It will be necessary for the Surveyors to visit the firm's works for the purpose of inspecting the welding plant, equipment and procedure and to arrange for the carrying out of preliminary tests similar to those described in 2010, 2011 and 2012.

On completion of the inspection and tests, the Surveyor's report including the results of the preliminary tests and particulars of the fusion welded pressure vessels previously constructed by the firm are to be submitted for the consideration of the Committee.

Routine Tests for Class 2 Fusion Welded Pressure Vessels

2002 Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported during welding that warping is reduced to a minimum.

2003 In cases where a number of Class 2 pressure vessels are made concurrently at the same works, and the plate thicknesses do not vary by more than 5 mm., each 37 metres of welded seam, longitudinal plus circumferential, may be regarded as equivalent to one pressure vessel, the required number of test specimens being provided accordingly.

In these cases the thickness of the test plates is to be equal to that of the thickest shell plate used in the construction of the pressure vessels.

2004 The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

2005 Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, or where the process for welding the circumferential joints is significantly different from that used for the longitudinal joints, when two test plates are to be prepared each having a welded joint which, so far as possible, is a duplication of the circumferential seams. Where a number of similar vessels are made at the same time, it will suffice if test plates are provided for each 30 metres of circumferential welded seam.

2006 The test plates are to be cut from the shell plate or plates forming the appropriate seam and before being detached are to be stamped by the Surveyor.

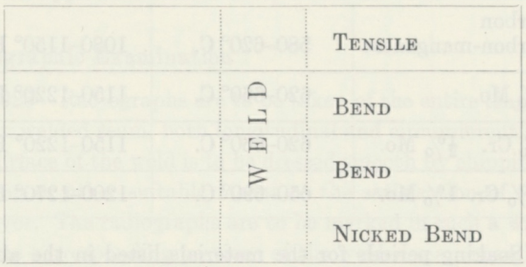
Where a number of similar welded pressure vessels are made concurrently at the same works, the test plates may be cut from one shell plate only provided the material is from the same cast.

When there is insufficient material available on the shell plates for the provision of test plates, acceptance may be given to test plates cut from another plate provided this plate is from the same cast and in the same heat treatment condition.

2007 The thickness of test plates is to be the same as that of the pressure vessel.

2008 One test plate is to be cut up into test specimens as shown in Fig. 11. All the specimens are to comply with the test requirements detailed in 2010 to 2012.

Fig. 11



Specimens may be dressed in way of the weld and the sharp edges may be removed from the bend specimens.

Retests

2009 If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

Tensile Test

2010 The shape of the specimen is to conform to the requirements of J 1920.

The ultimate tensile strength of the joint is to be not less than the minimum specified for the plate.

In case of Class 2A vessels if the test piece breaks in the plate or fusion zone at not less than 95% of the minimum specified for the plate the test may be accepted.

Bend Tests

2011 The width of the bend specimens is to be not less than 1,5 times the thickness, and the mid-portion of the specimens is to coincide with the centre line of the weld. One specimen is to be bent with the outer surface of the weld in tension, and the other specimen is to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through an angle of 180 degrees over a former, the diameter of which is not greater than three times the thickness of the specimen.

Nicked Bend Tests

2012 The specimen is to have a slot cut into each side of the weld. The specimen is then to be broken in the weld and the fracture is to reveal a sound homogeneous weld, substantially free from slag inclusions, porosity and coarse crystallinity.

Heat Treatment

2013 Where heat treatment is required to be carried out in respect of any pressure vessel, the requirements of J 1810 and J 1925 to J 1929 are to be complied with.

Hydraulic Test

2014 Hydraulic test to be carried out in accordance with the requirements of J 1930.

Section 21

REQUIREMENTS FOR CLASS 3 FUSION WELDING

Preliminary Conditions

2101 Pressure vessels of Class 3 grade will be accepted without routine weld tests if constructed by firms whose works are equipped to undertake the welding of pressure vessels of this type. The Surveyors are to be satisfied that the welding equipment, procedure and supervision of the work are adequate, and are to test the quality of the welds by preliminary tests and occasional tests at their discretion.

Hydraulic Test

2102 For pressure vessels intended for working pressures up to 7 kg. per cm.^{2}, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 7 kg. per cm.^{2} the hydraulic test pressure is to be 1,5 times the working pressure plus 3,5 kg. per cm.^{2}

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 22

CONSTRUCTION AND INSPECTION OF FUSION WELDED PRESSURE VESSELS

Note:—The following requirements are applicable to all classes of fusion welded pressure vessels.

Electrodes

2201 Electrodes intended for use in the construction of pressure vessels are to be stored in a dry place. In order to ensure that the quality of the electrodes is being consistently maintained they are to be subjected to a regular system of periodic testing and inspection. Where routine tests are frequently carried out in respect of pressure vessels made in the normal course of production, such tests may be regarded as meeting the requirements of this paragraph.

Welding Technique

2202 Welding may be carried out by hand or by machine, and the current used in electric metallic arc welding may be direct or alternating. In welding branch pieces, pads and compensating rings, more than one run of weld metal is to be deposited. Longitudinal and circumferential seams may be reinforced by additional runs of weld metal.

Preheating

2203 Preheating is to be employed when necessitated by the joint restraint, thickness of the plate, and composition of the materials to be welded. Irrespective of plate thickness, welds in carbon steel, where the tensile strength is 55 kg. per mm.^{2} or over, and welds in low alloy steels are to be preheated to a minimum temperature of 200° C. (392° F.). For carbon steels of lower tensile strength, preheating is to be used where the thickness exceeds 44,5 mm.

The method used for preheating is to be such as to ensure a uniformly heated band adjacent to the weld and to maintain the preheat temperature at all stages of welding until completion.

2204 The outer surfaces of the welds may be flush with the surfaces of the plates joined, but no objection will be raised if the total thickness at the centre of the weld is greater than the thickness of the plates, provided the change of section is gradual and there is no undercutting at the sides of the weld.

2205 Each run of weld metal is to be thoroughly cleaned and free from slag before the next run is deposited.

2206 Butt joints are to be welded from both sides of the plate where practicable. Before welding is commenced from the second side the weld metal at the bottom of the first side weld is to be removed by chipping or other approved method. Butt joints welded from one side, with or without backing strips, are acceptable only where access for an internal weld is not practicable. In the latter circumstances, it is to be demonstrated that there is complete penetration and fusion at the root of the weld.

2207 The welding of pressure vessels is to be carried out in the downhand horizontal position. In the case of circumferential seams means are to be adopted to ensure compliance with this requirement.

2208 In cases where it is proposed to adopt fusion welding processes in which it may not be possible to comply fully with the foregoing requirements regarding technique, full particulars are to be submitted for consideration.

Fabrication

2209 Before welding, the assembly is to be examined. The shape and size of the joints are to be in accordance with the approved design. The butting edges of the plates form-

ing the longitudinal and circumferential seams are to be in line within a limit of 10 per cent of the plate thickness, but in no case exceeding 3 mm. for longitudinal joints and 5 mm. for circumferential joints.

2210 The attachment of branches should be examined before and after welding.

2211 During fabrication, the Surveyor is to be provided with opportunities for seeing the actual deposition of weld metal. The joints are to be examined at various stages during construction.

2212 On completion of the welding, the seams are to be thoroughly examined before being dressed or machined. Parts showing evidence of blow-holes, slag inclusions, unsatisfactory penetration, porosity, or any other defect, are to be cut out and rewelded, and excessive undercutting made good.

2213 Each pressure vessel is to be calibrated for distortion. The calibration is to be made after the heat treatment has been carried out. The drum or shell is to be circular at any section within a limit of one per cent of the designed internal diameter based on the difference between the maximum and minimum diameters of any section. Any departure from circularity is to be gradual and there is to be no local flat in way of the welded seam.

Attachment of Fittings

2214 The attachment by welding of any fitting, brackets, lugs, etc., to the main pressure shell after the final stress relieving treatment, is not permitted, except where the material involved is mild steel. In such cases welding will only be permitted provided it is necessitated by the method of construction being employed and prior approval of the Surveyor must be obtained before any welding is carried out. In no circumstances is any welding to be done after heat treatment on vessels made of carbon or carbon-manganese steel with tensile strength exceeding 54 kg. per mm.^{2} or of alloy steel.

When fittings, lugs, etc., are attached by welding to the main pressure shell, the material of these attachments is to be of weldable quality and the welding is to be of a comparable standard to that required for the vessel.

Section 23

FORGE WELDED PRESSURE VESSELS

General

2301 The term forge weld is, for the purpose of these Rules, applicable to joints made between plates which are welded together by means of hammering or rolling and in which no added metal is included.

Classification of Forge Welded Pressure Vessels

2302 Class 1. Pressure vessels made in accordance with the requirements of this class will be accepted only if they are constructed by firms whose names are included in the list of firms recognised by the Committee for the manufacture of Class 1 forge welded pressure vessels.

Approval of the following pressure vessels will only be given provided they be constructed and tested in accordance with the requirements of these Rules.

Pressure parts of boilers, and all fired pressure vessels intended for working pressures above 3,5 kg. per cm.^{2}

In special circumstances relating to pressure, temperature and service conditions, it may be considered necessary to include other pressure vessels in the Class 1 category.

Class 2. This class includes all forge welded pressure vessels not included in Class 1.

Cylindrical Shells

2303 For pressure vessels operating at metal temperatures of 343° C. and under, the thickness of cylindrical shells is to be determined by the following formula, but no plate is to be less than 6,5 mm. thick.

$$WP = \frac{K \times S}{D}(T-1,6), \qquad T = \frac{WP \times D}{K \times S} + 1,6$$

where WP = working pressure in kg. per cm.^{2},

T = thickness of shell in mm.,

S = minimum tensile strength in kg. per mm.^{2},

D = internal diameter of shell in mm.,

K = 40 for Class 1 vessels,

= 35 for Class 2 vessels with shells 16 mm. thick and above,

= 32,5 for Class 2 vessels with shells less than 16 mm. thick.

2304 For Class 1 pressure vessels operating at metal temperatures exceeding 343° C. the thickness of cylindrical shells is to be determined by the appropriate formula of J 1602 in association with the permissible stresses at temperature of Table 1 for carbon and carbon-manganese steel.

Material

2305 The material used in the construction of pressure vessels is to be manufactured and tested in accordance with the relevant requirements of Chapter P.

The tensile strength of the material is to be between 38 and 47 kg. per mm.^{2} with a range not exceeding 6,3 kg. per mm.^{2} in any one case.

Preliminary Conditions and Tests for Class 1 Forge Welding

2306 In order that the name of a firm may be included in the list of firms recognised by the Committee for the manufacture of Class 1 forge welded pressure vessels, it will be necessary for the Surveyors to make a preliminary visit to the works for the purpose of inspecting the welding plant, equipment and procedure, also to arrange for the carrying out of a special series of tests as described in 2309. Subsequently the Surveyors will report periodically to the Committee on the conditions which obtain at the works, and if considered necessary will carry out further tests.

2307 The welding plant and equipment are to be of good quality and maintained in efficient working condition. The welding plant is to be installed under cover and arranged so that the welding work may be carried out in positions free from draughts and adverse weather conditions. The procedure is to be such that there is regular and systematic supervision of the welding work.

2308 The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, and micro-examination. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control, but as an alternative, arrangements may be made whereby pressure vessels can be heat treated elsewhere.

2309 A series of special preliminary tests to demonstrate the quality of the welding work is to be carried out. The tests should include tensile, bend, impact, hardness and fatigue tests on specimens which should be prepared in a similar manner to that used in the making of longitudinal joints in pressure vessels. The Surveyors are to select portions of the test plates from which photomicrographs, at 100 and 300 magnifications, are to be prepared representing the weld centre and the plate remote from the weld.

2310 A full size pressure vessel is to be manufactured under survey, and is to comply in every respect with the requirements for Class 1 forge welded pressure vessels.

2311 In the case of firms of large experience some modification may be permitted in regard to the requirements of 2309, provided satisfactory evidence is produced of successful results obtained by the firm's welding methods, over an appreciable period.

Routine Tests for Forge Welded Pressure Vessels

Class 1

2312 The shell plates of each pressure vessel are to be left long enough to accommodate the following test specimens:—

Two tensile specimens, } with provision
Four bend specimens, } for retests.

Retests

2313 If any of the tests fail, two retests are to be made, both of which are to comply fully with the test requirements.

Tensile Test

2314 The tensile specimens are to conform to the standard test piece A (*see* P 312), and the mid portion of the specimens is to coincide with the centre line of the weld.

The ultimate tensile strength of both test pieces is to be not less than 95 per cent of the minimum specified for the plate material. The elongation is to be not less than 18 per cent on a gauge length of 200 millimetres.

Bend Tests

2315 The width of the bend specimens is to be not less than 1,5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. Two specimens are to be bent in such a manner that the outer surface of the weld is in tension, and two specimens are to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through 180 degrees round a former, the diameter of which is not greater than three times the thickness of the specimen.

NOTE:—Some modification of the requirements contained in 2312 may be permitted in circumstances such as are indicated in 2311.

Test Pieces for Circumferential Seams

2316 In the case of pressure vessels having circumferential joints only, no test pieces need be provided unless the internal diameter of the pressure vessel exceeds 1370 mm., when a representative welded joint is to be made and cut up to provide the specimens detailed above.

Class 2

2317 In the case of forge welded pressure vessels other than those included in Class 1, routine tests are not required in respect of longitudinal joints, but where the

internal diameter of a pressure vessel exceeds 1370 mm. the manufacturer is to produce authoritative evidence of test results demonstrating that efficient circumferential welds of the proposed dimensions can be made consistently.

Weld Thickness

2318 On completion of the welding the thickness at and adjacent to the weld is to be not less than the required thickness of the shell plate as determined from the formulæ for working pressure given in J 1602, J 1603 and J 1815.

Heating

2319 The heating of plates for welding is to be carried out by means of a process which will provide a flame which will not be of an oxidizing character and will not tend to introduce impurities into the steel. Provision is to be made for careful control of the welding heat.

Heat Treatment

2320 All forge welded pressure vessels are to be efficiently normalised by heating uniformly to a temperature of 920° C. (1690° F.) and allowed to cool in still air.

The heat treatment is to be carried out in accordance with the requirements of J 1925 to J 1929, so far as these are applicable.

Hydraulic Test

2321 Pressure vessels are to be subjected to a hydraulic test pressure of twice the working pressure. Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 24

AIR RECEIVERS

2401 Cylindrical receivers for containing air under high pressure may be made either of seamless steel or of welded, or riveted, steel plates.

Welded Receivers

2402 Receivers of fusion or forge welded construction are to comply with the requirements of J 18 to J 23.

Riveted Receivers

2403 Receivers of riveted construction are to comply with the Rules for cylindrical boilers, where applicable.

Dished End Plates

2404 Where end plates are dished to partially spherical form and not fitted with stays, the scantlings may be determined by the following formula:—

$$WP = \frac{C \times S \times T}{R}$$

where WP = working pressure, in kg. per cm.^{2}

C = 25,7 for ends concave to pressure,

= 16,5 for ends convex to pressure,

S = minimum tensile strength of the plates, in kg. per mm.^{2}

T = thickness of the end, in mm. after dishing,

R = inside radius of curvature of the end, in mm. which is not to exceed the diameter of the shell.

Ends convex to pressure are not to be used for receivers exceeding 610 mm. internal diameter.

If desired the formula J 1605 may be used in determining the scantlings of dished ends subject to pressure on the concave side.

The inside corner radius is to be not less than four times the thickness of the end plate and in no case less than 64 mm.

Where the end is provided with a flanged manhole the thickness of the end, in mm. determined by the foregoing formula is to be increased by 3 mm. and the depth (F) of the manhole flange, measured in mm. from the outer surface at the minor axis is to be not less than

$$F = \sqrt{T_1 \times W}$$

where T_1 = required thickness of the end plate, in mm.

W = minor axis of the manhole, in mm.

Seamless Receivers

2405 The material used is to comply with the requirements of P 322.

2406 The permissible working pressure for seamless receivers is to be determined by the following formulæ:—

$$WP = \frac{C \times S \times (t - 3{,}2)}{D}$$

for thicknesses of 16 mm. and above.

$$WP = \frac{C \times S \times (t - 1{,}6)}{D}$$

for thicknesses below 16 mm.

where WP = working pressure, in kg. per cm.^{2},

S = minimum tensile strength of the steel shell plates, in kg. per mm.^{2},

t = thickness of the shell plates, in millimetres,

D = internal diameter, in millimetres,

C = 55 for receivers of thickness 16 mm. and above,

49 for receivers of thickness below 16 mm.

2407 Each seamless receiver is to be carefully annealed after manufacture, and before the hydraulic test.

Hydraulic Test

2408 Each seamless receiver is to be subjected to a hydraulic test of twice the working pressure, which it is to withstand without permanent set.

2409 Each receiver made of riveted steel plates for pressures up to 21 kg. per cm.^{2} is to be tested by hydraulic pressure to 1,5 times the working pressure, plus 3,5 kg. per cm.^{2} Where higher working pressures are used, the test pressure need not be more than 14 kg. per cm.^{2} above the working pressure.

General

2410 All receivers above 150 mm. internal diameter are to be so made that the internal surfaces may be examined and, wherever practicable, the openings for this purpose are to be sufficiently large for access. Means are to be provided for cleaning the inner surfaces by steam, or otherwise.

2411 Each receiver which can be isolated from a safety valve is to be provided with a suitable fusible plug to discharge the contents in case of fire. The melting point of the fusible plug is to be approximately 150° C. (*See also* F 310.)

Where carbon dioxide gas is used for fire extinguishing, it is recommended that the discharge from the fusible plug be piped to deck.

2412 Each receiver is to be fitted with a drain arrangement at its lowest part, permitting oil and water to be blown out.

Cross-reference

2413 For scantlings of compressed air pipes, *see* E 506 and E 512.

Periodical Surveys

2414 For periodical survey requirements, *see* Chapter C.

Section 25

PRESSURE VESSELS FOR THE CARRIAGE OF LIQUEFIED PETROLEUM GASES

General

2501 The requirements of this Section are applicable to welded steel pressure vessels of cylindrical or spherical form intended for the carriage of liquefied petroleum gas under pressure at ambient or lower temperatures. The vessels should be constructed generally in accordance with the Rules for Welded Pressure Vessels Class 1 and installed in closed holds with the vessels and their mountings protruding above the weather deck.

See E 12 for requirements for filling, discharging, venting and inerting pipe arrangements, tank connections and mountings, cargo pumps and compressors and other associated equipment.

See D 70, D 71 and D 72 for ship requirements for the carriage of liquefied gases.

Plans

2502 Before construction of the vessels is commenced the following particulars where applicable and plans are to be submitted for approval:—

(1) Nature of cargoes, together with maximum vapour pressure and minimum liquid temperature for which the pressure vessels are to be approved, and proposed hydraulic test pressure.

(2) Particulars of materials proposed for the construction of the vessels. (*See* 2503.)

(3) Particulars of refrigeration equipment.

(4) General arrangement plan showing location of pressure vessels in the ship.

(5) Plan of pressure vessel showing attachments, openings, dimensions, details of welded joints and particulars of proposed stress relief heat treatment.

(6) Plan of seatings, securing arrangements and deck sealing arrangements.

(7) Plan showing arrangement of mountings, level gauges and number, type and size of safety valves.

Materials

2503 Plate materials are to be manufactured and tested in accordance with the requirements of P 3 and the specification of the material is to be submitted for approval as

required by P 307 for steels operating at low metal temperatures. In addition to the tensile and bend test requirements the tests of plates at the steel works are to include Charpy V-notch impact tests at the design metal temperature.

For pressure vessels where the carrying temperature is 0° C. or less, specifications of the weld metal as well as the plate material, including Charpy V-notch impact properties at the carrying temperatures, are to be submitted for approval. For pressure vessels where the cargo is carried at atmospheric temperature the plate material is to have minimum impact properties of 4,84 kgm. at 0° C. For details of impact tests *see* P 207 and P 208. Tests to determine the impact strength of weld metal should have regard to variations in welding positions.

Design

2504 For pressure vessels where the cargo is carried at atmospheric temperature, the vapour pressure used for design purposes is to be not less than the vapour pressure of the liquefied gas at 45° C.

The thickness at any part of the pressure vessel is not to be less than determined by the formulae in J 1815 and J 1816 for a working pressure appropriate to the vapour pressure and static liquid head. The thickness so obtained is to be increased where necessary to take account of the following:—

(a) local stresses in shell and ends due to reactions from seatings and securing fitments when the ship is upright or listed up to 30°,

(b) thermal expansion and contraction effects where the liquid cargo is to be carried at temperatures below ambient,

(c) dynamic loading from rolling, pitching and heaving of the ship in a seaway to the extent given in D 7116. Alternatively, provision for dynamic loading can be made by assuming that pressures due to static head are doubled.

The sum of all stresses due to static and dynamic loading is not to exceed one third of the tensile strength of the material.

Special attention is to be given to the design of attachments welded to the pressure vessel for supporting or securing purposes so as to minimise stress concentrations at these points.

Seatings are to be so designed as to ensure adequate and uniform support to the pressure vessel having due regard to deflections of the hull structure in a seaway.

All valves, fittings and manholes are to be located on that portion of the pressure vessel which protrudes above the weather deck, and are to be protected from damage and corrosion. Manholes should be placed above the liquid level. Valves and fittings are to be of steel or other approved ductile material.

The sealing arrangements at deck are to provide for expansion and contraction of the vessel under normal operating pressure and temperature and are to be watertight.

Suitable arrangements are to be made to prevent the pressure, temperature and liquid level in the tanks from rising above safe limits. Details are to be submitted; also it should be stated whether the safety arrangements are controlled by statutory requirements of any National Authority.

Refrigeration Equipment

2505 Where refrigeration equipment is installed, two or more refrigerating units are to be provided of capacity sufficient to maintain the liquid cargo at the carrying temperature with any one unit out of use. (*See* E 1228.)

Construction and Tests

2506 In general, pressure vessels are, so far as practicable, to be constructed and tested to the Rules for Class 1 Welded Pressure Vessels, except that the work may be carried out by manufacturers not appearing on the Society's Class 1 List, provided fabrication and tests are completed to the satisfaction of the Surveyors.

Some relaxation of Class 1 requirements as regards tests and heat treatment may be permitted dependent on design, scantlings and material of the vessel, but generally, welded joints should be subjected to radiographic examination. Where the pressure vessels are too large for furnace stress relief, proposals for local stress relief and stress relief of prefabricated components will be considered.

Where plates are hot formed to shape, check tests including impact tests are to be made on the material as required in P 310. Where a large number of plates are involved, check tests on selected plates will suffice, provided the Surveyor is satisfied that the hot forming process is closely controlled.

For pressure vessels where the operating metal temperature is 0° C. or less, provision is to be made for Charpy V-notch impact tests of the welded joints in addition to the other tests specified in J 1916. Test pieces are to be cut transverse to the direction of the weld and the notches are to be located in the weld metal normal to the plate surface. Not less than 3 test pieces are required from each test plate. The impact tests are to be made at the carrying

temperature for which the vessel is approved and the test results are to comply with approved specification. (*See* 2503.)

Hydraulic Tests

2507 The pressure vessel is to be tested as required by J 1930 but the hydraulic test pressure is to be 1,5 times the design pressure for the weakest part of the vessel. The static head of the water may be included in the test pressure if the amount is significant.

On completion, the vessels are to be clearly marked with the maximum vapour pressure and minimum carrying temperature.

28th January, 1965

APPENDIX

Firms recognised by the Committee for the Manufacture of Class 1 Welded Pressure Vessels.

Note: The Society's Office giving attendance at the Works is shown in brackets.

FUSION WELDING

United Kingdom

Adamson & Hatchett, Ltd., Dukinfield, Cheshire. (Manchester.)

Adamson, Joseph & Co., Ltd., Hyde, Cheshire. (Manchester.)

Aiton & Co., Ltd., Derby. (Nottingham.)

Ashmore, Benson, Pease & Co., Ltd., South Works, Stockton-on-Tees. (Middlesbrough.)

Babcock & Wilcox, Ltd., Renfrew. (Glasgow.)

Balfour, Henry & Co., Ltd., Leven, Fife. (Leith.)

Brown, John & Co., Ltd., Clydebank. (Glasgow.)

Brown, John, Land Boilers Ltd., Whitecrook Works, Clydebank. (Glasgow.)

Butterfield, W. P. (Engineers) Ltd., P.O. Box No. 38, Shipley, Yorks. (Leeds.)

Cammell Laird & Co. (Shipbuilders & Engineers), Ltd., Birkenhead. (Liverpool.)

Clark, George & N.E.M., Ltd., Wallsend. (Newcastle.)

Clark, George & N.E.M., Ltd., Southwick Eng. Works. (Sunderland.)

Clarke, Chapman & Co., Ltd., Gateshead. (Newcastle.)

Clayton, Son & Co., Ltd., Pepper Road Works and Moor End Works, Hunslet, Leeds. (Leeds.)

Cochran & Co., Annan, Ltd., Annan. (Glasgow.)

Danks, Edwin & Co. (Oldbury), Ltd., (Birmingham.)

Danks of Netherton, Ltd., Netherton. (Birmingham.)

Davey, Paxman & Co., Ltd., Standard Ironworks, Colchester, Essex. (London.)

English Electric Co., Ltd., Netherton Works, Netherton, Lancs. (Liverpool.)

English Electric Co., Ltd., Stafford. (Birmingham.)

Farrar Boilerworks, Ltd., Newark-on-Trent. (Nottingham.)

Firth Brown, Ltd., Atlas Works, Sheffield. (Sheffield.)

Foster, Yates & Thom, Ltd., Canal Works, Blackburn. (Manchester.)

Grazebrook, M. & W., Ltd., Dudley, Worcestershire. (Birmingham.)

Harland & Wolff, Ltd., Belfast. (Belfast.)

Harvey Fabrication, Ltd., London, S.E.7. (London)

Head Wrightson Teesdale, Ltd., Thornaby-on-Tees. (Middlesbrough.)

Horseley Bridge & Thomas Piggott, Ltd., Tipton, Staffs. (Birmingham.)

International Combustion, Ltd., Derby. (Nottingham.)

Jenkins, Robert & Co., Ltd., Rotherham. (Sheffield.)

Marshall & Anderson, Ltd., Manse Road, Motherwell. (Broomside Works). (Glasgow.)

Marshall, Sons & Co., Ltd., Britannia Works, Gainsborough. (Sheffield.)

Millspaugh, Ltd., Sheffield. (Sheffield.)

Motherwell Bridge & Engineering Co., Ltd., Motherwell. (Glasgow.)

Newton Chambers Engineering, Ltd., Thorncliffe, Nr. Sheffield. (Sheffield.)

Old Park Engineering Co., Ltd., Dudley, Worcs. (Birmingham.)

Penman & Co., Ltd., Glasgow. (Glasgow.)

Redheugh Iron & Steel Co., Ltd., Teams, Gateshead, Co. Durham. (Newcastle.)

Robey & Co., Ltd., Globe Works, Lincoln. (Nottingham.)

Ruston & Hornsby, Ltd., Lincoln. (Nottingham.)

Steels Process Plants, Ltd., Crown Works, Sunderland. (Sunderland.)

Stephen, Alexander & Sons, Ltd., Glasgow. (Glasgow.)

Thompson Bros. (Bilston) Ltd., Bilston, Staffs. (Birmingham.)

Thompson, John (Dudley) Ltd., Dudley. (Birmingham.)

Thompson, John (Wolverhampton) Ltd., Wolverhampton. (Birmingham.)

Towler & Son, Ltd., London, E.15. (London.)

Vickers-Armstrongs, Ltd., Engineering Group, Armament & Commercial Eng. Division, Vickers-Armstrongs Elswick Works, Newcastle-on-Tyne. (Newcastle.)

Watson, Robert & Co. (Constructional Engineers), Ltd., Bolton, Lancs. (MANCHESTER.)
Weir, G. & J., Ltd., Cathcart, Glasgow. (GLASGOW.)
Whessoe, Ltd., Darlington. (MIDDLESBROUGH.)
Yarrow & Co., Ltd., Scotstoun, Glasgow. (GLASGOW.)

Australia

Babcock & Wilcox of Australia Pty., Ltd., Regents Park, N.S.W. (SYDNEY.)
Perry Engineering Co., Ltd., Adelaide, S. Australia. (ADELAIDE.)
Smith, Bernard Pty. Ltd., Sydney, N.S.W. (SYDNEY.)
Steelweld Fabrications Pty. Ltd., Braybrook, Victoria. (MELBOURNE.)
Thompsons (Castlemaine), Ltd., Melbourne, Victoria. (MELBOURNE.)
Vickers Hoskins Pty., Ltd., Bassendean, Western Australia. (FREMANTLE.)

Austria

Vereinigte Osterreichische Eisen-und-Stahlwerke Aktiengesellschaft, Linz an der Donau. (VIENNA.)
Waagner-Biro Aktiengesellschaft, Graz, Styria. (VIENNA.)

Belgium

Cockerill-Ougree, S.A., Seraing. (ANTWERP.)

Canada

Babcock-Wilcox & Goldie McCulloch, Ltd., Galt, Ontario. (TORONTO.)
Canadian Vickers Industries, Ltd., Montreal. (MONTREAL.)
Davie Shipbuilding, Ltd., Lauzon, P.Q. (QUEBEC.)
Dominion Bridge Co., Ltd., Lachine, Quebec. (QUEBEC.)
Foster Wheeler, Ltd., St. Catherines, Ontario. (TORONTO.)
Vancouver Iron & Engineering Works, Ltd., Vancouver, B.C. (VANCOUVER.)

Denmark

Aalborg Vaerft A/S, Aalborg. (AALBORG.)
Burmeister & Wain A/S, Copenhagen. (COPENHAGEN.)
Helsingor Skibsvaerft & Maskinbyggeri, Elsinore. (COPENHAGEN.)

Finland

Oy Wartsila A/B, Helsinki Works, Helsingfors. (HELSINGFORS.)
Valmet Oy, Rautpohjan tehdas, Jyvaskyla. (HELSINGFORS.)

France

Ateliers & Chantiers de Nantes (Bretagne Loire). (NANTES.)
Brissoneau & Lotz, Nantes. (NANTES.)
Chantiers de l'Atlantique (Penhoet-Loire), St. Nazaire. (NANTES.)
Chantiers Navals de la Ciotat, Etablissement du Trait, Le Trait. (ROUEN.)
Compagnie de Fives-Lille, Fives-Lille, Nord. (VALENCIENNES.)

Germany

Babcock Werke, Oberhausen/Rheinland. (DUSSELDORF.)
Borsig A.G., Berlin-Tegel. (BERLIN.)
Bremer-Vulkan, Bremen-Vegesack. (BREMEN.)
Deutsche Werft A.G., Hamburg. (HAMBURG.)
Dinglerwerke A.G., Zweibruecken, Werke in Zweibruecken und Bierbach-Saar. (SAARBRUCKEN-SAAR.)
Gutehoffnungshutte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade. (DUSSELDORF.)
Kieler Howaldtswerke A.G., Kiel. (KIEL.)
Klockner-Werke A.G., Georgsmarienwerke, Osnabruck, Werke Georgsmarienhutte. (HANOVER.)
Koerver & Lersch, Krefeld. (DUSSELDORF.)
Krupp, Fried., Maschinenfabriken, Essen. (DUSSELDORF.)
Mannesmann A.G. Rohr-und Bodenwerk Huckingen, Duisburg-Huckingen. (DUSSELDORF.)
Maschinenfabrik Augsburg-Nurnberg A.G., Augsburg. (AUGSBURG.)
Maschinenfabrik Augsburg-Nurnberg A.G., Gustavsburg. (MANNHEIM.)
Maschinenfabrik Augsburg-Nurnberg A.G., Werk Hamburg, Hachmannkai, Hamburg, 11. (HAMBURG.)
Phoenix-Rheinrohr A.G., Works Thyssen, Mulheim, Ruhr. (DUSSELDORF.)
Pintsch-Bamag A.G., Alteburgerstr. 300, Koln-Bayenthal. (KOLN.)
Rheinstahl Huettenwerke A.G., Werk Ruhrstahl Henrichshuette, Hattingen-Ruhr. (DORTMUND.)
Rheinstahl Huettenwerke A.G., Werk Ruhrstahl Presswerke Brackwede, (HANOVER.)
Siller & Jamart, Wuppertal Barmen. (DUSSELDORF.)
Stahl-und-Rohrenwerke Reisholz G.m.b.H., Dusseldorf-Reisholz. (DUSSELDORF.)

Steinmuller, L. & C., G.m.b.H., Gummersbach/Rhld. (HAMBURG.)
Weser A.G., Bremen. (BREMEN.)

Holland

"Breda" N.V. Machinefabrik, v/h Backer & Rueb, Rotterdam. (ROTTERDAM.)
Bronswerk-Feyenoord Afd. AMAF N.V. (AMSTERDAM.)
Dok-en Werft-Maatschappij Wilton-Fijenoord N.V., Schiedam. (ROTTERDAM.)
Jonker N.V. Hk., & Zoon, Amsterdam. (AMSTERDAM.)
Kon. Mij. "De Schelde" N.V., Vlissingen. (ROTTERDAM.)
Nederlandsche Dok en Scheepsbouw Mij. (AMSTERDAM.)
Nederlandsche Electrolasch Mij. N.V., Leiden. (ROTTERDAM.)
Rotterdamsche Droogdok Maatschappij N.V., Rotterdam. (ROTTERDAM.)
Stork, Gebr. & Co., N.V., Hengelo. (AMSTERDAM.)
Werkspoor N.V., Amsterdam. (AMSTERDAM.)

Italy

Acciaieria & Tubificio di Brescia, Brescia. (GENOA.)
Ansaldo Stabilimento Meccanico, Genoa. (GENOA.)
Bonaldi D. & Co., S.p.A., Crema. (MILAN.)
Cantieri Riuniti dell'Adriatico. (TRIESTE.)
C.I.P.I. Costruzioni Impianti Petroliferi Industriali, Marghera, Venice. (Also known as Guido Sartori). (VENICE.)
Franco Tosi, S.p.A., Legnano. (GENOA.)
Nuovo Pignone, Industrie Meccaniche e Fonderia S.p.A., Stabilimento di Massa, Apuania. (GENOA.)
Terni, Societa per l'Industria e l'Elettricita, Terni. (NAPLES.)

Japan

Babcock-Hitachi K.K., Kure Works, Kure. (HIROSHIMA.)
Babcock-Hitachi K.K., Yokohama. (YOKOHAMA.)
Chiyoda Chemical Engineering & Construction Co., Ltd., Kawasaki Factory, Kawasaki. (YOKOHAMA.)
Fuji Electric Co., Ltd., Kawasaki Factory, Kawasaki. (YOKOHAMA.)
Fujinagata Shipbuilding & Engineering Co., Ltd., Osaka. (KOBE.)
Hitachi Ltd., Hitachi Works, Ibaraki-ken. (YOKOHAMA.)
Hitachi Shipbuilding & Eng. Co., Ltd., Innoshima Shipyard, Innoshima. (KOBE.)
Hitachi Shipbuilding & Eng. Co., Ltd., Sakurajima Works, Osaka. (KOBE.)
Ishikawajima-Harima Heavy Industries Co., Ltd., Aioi. (KOBE.)
Ishikawajima-Harima Heavy Industries Co., Ltd., Nagoya Shipyard. (KOBE.)
Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo. (YOKOHAMA.)
Kawasaki Dockyard Co., Ltd., Kobe. (KOBE.)
Kobe Steel Works Ltd., Okubo Plant, Akashi City. (KOBE.)
Maizuru Shipbuilding & Engineering Co., Ltd., Maizuru Shipyard, Maizuru. (KOBE.)
Mitsubishi Heavy Industries Ltd., Kobe Shipyard & Engine Works, Kobe. (KOBE.)
Mitsubishi Heavy Industries Ltd., Hiroshima Shipyard & Engine Works, Hiroshima. (HIROSHIMA.)
Mitsubishi Heavy Industries Ltd., Nagasaki Shipyard & Engine Works, Nagasaki. (NAGASAKI.)
Mitsui Shipbuilding & Engineering Co., Ltd., Tamano. (KOBE.)
Nippon Kokan K.K., Tsurumi Shipyard. (YOKOHAMA.)
Uraga Heavy Industries Ltd., Uraga Machinery Factory, Yokosuka. (YOKOHAMA.)
Yokohama Shipyard & Eng. Works, Mitsubishi Heavy Industries Ltd., Yokohama. (YOKOHAMA.)
Yokoyama Engineering Co., Ltd., Kawasaki Works, (YOKOHAMA.)

Norway

Elektrisk Sveisning A/S, Toyenbekken 34, Oslo. (OSLO.)
Fredriksstad Mek. Verksted, Fredrikstad. (OSLO.)
Kvaerner Brug A/S, Oslo. (OSLO.)

Poland

Huta Ferrum, Katowice. (GDANSK.)
Stocznia Gdansk (Gdansk Shipbuilding, Marine Engineering & Boiler Works), Gdansk. (GDANSK.)

South Africa

Barlow Head Wrightson, Ltd., Benoni, Transvaal. (VEREENIGING.)
Thompson, John, Africa (Pty.), Ltd., Bellville, Cape Province. (CAPE TOWN.)
Vanderbijl Engineering Corporation, Ltd., Duncanville Works, Houtkop Road, Duncanville. (VEREENIGING.)

Spain

Empresa Nacional Bazan, El Ferrol. (BILBAO.)
La Maquinista Terrestre y Maritima S.A., Barcelona. (BARCELONA.)
S.E. de C. Babcock & Wilcox S.A., Galindo Works, Bilbao. (BILBAO.)

Sweden

Aktiebolaget Gotaverken, Gothenburg. (GOTHENBURG.)
Andersson, J. R., & Co. A/B, Kallhall. (STOCKHOLM.)
Avesta Jernverks A/B, Avesta. (STOCKHOLM.)
Broderna Hedlund A/B, Stockholm. (STOCKHOLM).
Eriksbergs Mek. Verkstads A/B, Gothenburg. (GOTHENBURG.)
Karlskronavarvet A.B., Karlskrona. (MALMO.)
Landsverk A/B, Landskrona. (HELSINGBORG.)
Lindholmens Varv A/B, Gothenburg. (GOTHENBURG.)
Motala Verkstad A/B, Motala. (GOTHENBURG.)
Svenska Metalock A/B, Gothenburg. (GOTHENBURG.)
Uddeholms Aktiebolag, Degerfors Jernwerk, Degerfors. (GOTHENBURG.)

Switzerland

Brown, Boveri Ltd., Baden. (WINTERTHUR.)
Sulzer Brothers Ltd., Winterthur. (WINTERTHUR.)

U.S.A.

Babcock & Wilcox Co., Barberton, Ohio. (CLEVELAND.)
Chicago Bridge & Iron Co., Birmingham, Alabama. (MOBILE.)
Combustion Engineering Co., Inc., Chattanooga, Tennessee. (MOBILE.)
Foster Wheeler Corporation, Mountaintop, Pa. (PHILADELPHIA.)

Yugoslavia

Djuro Djakovic, Slavonski Brod. (RIJEKA.)
Tvornica Parnih Kotlova, Zagreb. (RIJEKA.)

FORGE WELDING

Thompson, John (Wolverhampton), Ltd., Wolverhampton. (BIRMINGHAM.)

October, 1966

Chapter K

SPARE GEAR FOR STEAM AND INTERNAL COMBUSTION MACHINERY INSTALLATIONS

THE FOLLOWING ARTICLES OF SPARE GEAR, SO FAR AS THEY ARE APPLICABLE, ARE TO BE CARRIED. ITEMS USED ARE TO BE REPLACED OR MADE GOOD BY THE OWNERS AS OPPORTUNITY OCCURS.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	MAIN PROPELLING MACHINERY			
	STEAM RECIPROCATING ENGINES (*See also* items 20 and 21)			
1	Connecting Rod Bearings	1	1	Bottom end bearing complete with liners, bolts and nuts.
		1	1	Top end bearing complete with liners, bolts and nuts for one connecting rod.
2	Piston Rings	1 set	1 set	Rings and springs for H.P. Piston.
3	Piston Valve Rings	1 set	—	Rings and springs, of each size used.
4	Piston Rod Metallic Packing	1	—	Complete set of packing for H.P. piston rod and valve spindle.
5	Poppet Valves	1	—	Valve complete with cage, spindle and bush, of each size used, together with rollers and springs.
	STEAM TURBINES (*See also* items 20 and 21)			
6	Bearing Bushes	1	—	Complete bearing bush, of each size and type used, for the rotor, pinion and gear wheel shafts, for one engine.
7	Turbine Thrust	1 set	1 set	Pads of each size for one face of Michell type thrust, or rings for turbine adjusting block, of each size used for one engine. Assorted liners for 1 block where fitted.
	OIL ENGINES (*See also* items 20 and 21)			
8	Valves	2	2	Exhaust valves complete with valve casings, springs and other fittings.
		1	1	Air inlet valve complete with valve casing, springs and other fittings.
		1	1	Starting air valve on cylinder complete with valve casing, springs and other fittings.
		½ set	¼ set	Fuel valves, of each size and type used, complete with all fittings, for one engine.
		1	1	Cylinder relief valve complete.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
9	Piston (including piston exhaust valves where used)	1	—	*Crosshead Type.* Piston, of each size used, complete with rings, studs and nuts.
		1	—	*Trunk Piston Type.* Piston of each size used, complete with skirt, rings, studs, nuts and gudgeon pin.
10	Piston Rings (including rings for piston exhaust valves where used)	1 set	1 set	Rings, of each size used, for one cylinder.
11	Piston Cooling Pipes	2 sets	1 set	Telescopic cooling pipes and fittings or their equivalent, for a cylinder unit.
12	Connecting Rod Bearings	1	1	Bottom end bearing of each type fitted complete with liners, bolts and nuts.
		1	—	Top end bearing of each type fitted complete with liners, bolts and nuts.
		1	1	Gudgeon pin bush, where trunk pistons are used.
13	Scavenge Blower NOTE : Where there are two scavenge blowers connected to all cylinders, spare gear may be omitted provided the engines can manœuvre satisfactorily when one of the blowers is not in action.	1 set	—	Rotors, rotor shafts, bearings and synchronising gear wheels or equivalent working parts if of other types.
14	Valves for Scavenge System	½ set	½ set	Suction and delivery valves, for one engine.
15	Gear and Chain Drives for Camshafts, Scavenge Blowers, Compressors, Fuel Pumps, Cooling Water Pumps, Bilge Pumps and Lubricating Oil Pumps (excluding cylinder lubricators).	1 set	—	*Gear Wheel Drive.* Wheels for the drive of one engine.
		6	—	*Chain Drive.* Separate links with pins and rollers of each size used.
16	Fuel Pumps	1	1	One pump unit complete where a separate pump is provided for each cylinder, or One complete set of working parts for one pump where several pumps are grouped in one body, plus one body.
17	Reduction and/or Reverse Gear Case Bearing Bushes	1	—	Complete bearing bush, of each size fitted in the gear case assembly.
		1	—	Roller or ball race, of each size fitted in the gear case assembly.
18	Main Engine Driven Air Compressor	1 set	1 set	Piston rings of each size used.
		½ set	½ set	Suction and delivery valves complete, of each size used.
19	Fuel Pipes	1	1	Length of pipe of the greatest length used, complete with flanges or unions, for the fuel delivery to the cylinders.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	APPLICABLE TO ALL TYPES OF MAIN ENGINES			
20	Main Thrust Blocks	1 set	1 set	Pads for one face of Michell type thrust block
				or
		1	1	Complete white metal thrust shoe of solid ring type
				or
		1	1	Inner and outer race with rollers where roller thrust bearings are used.
21	Coupling Bolts	1 set	—	Bolts, of each size used, for one coupling.
	ELECTRIC PROPELLING MACHINERY	For items of spare gear to be carried *see* M 21.		

AUXILIARY MACHINERY

Where additional units of adequate capacity are fitted no spare gear is required.

	AUXILIARY OIL ENGINES	For each size of engine required for essential services.		
22	Valves	2	2	Exhaust valves complete with valve casings, springs and other fittings.
		1	1	Air inlet valve, complete with valve casing, springs and other fittings.
		1	1	Starting air valve on cylinder complete with valve casing, springs and other fittings.
		½ set	¼ set	Fuel valves of each size used, complete with all fittings, for one engine.
		1	1	Cylinder relief valve complete.
23	Piston Rings	1 set	1 set	Rings of each size used, for one cylinder.
24	Piston Cooling Pipes	2 sets	1 set	Telescopic cooling pipes and fittings or their equivalent, for a cylinder unit.
25	Connecting Rod Bearings	1	1	Bottom end bearing of each type fitted complete with liners, bolts and nuts.
		1	1	Gudgeon pin bush, where trunk pistons are used.
26	Valves for Scavenge System	¼ set	¼ set	Suction and delivery valves, for one engine.
27	Fuel Pumps	1	1	One pump unit complete where a separate pump is provided for each cylinder, or One complete set of working parts for one pump where several pumps are grouped in one body, plus one body.
28	Fuel Pipes	1	1	Length of pipe of the greatest length used, complete with flanges or unions, for the fuel delivery to the cylinders.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	AUXILIARY STEAM ENGINES	For each size of engine required for essential services.		
29	Connecting Rod Bearings	1	1	Bottom end bearing complete with liners, bolts and nuts.
		1	1	Top end bearing complete with liners, bolts and nuts.
30	Piston Rings	1 set	1 set	Rings.
	TURBINES DRIVING ESSENTIAL AUXILIARIES	Spare gear to be the same as for main steam turbines in so far as applicable.		
	AUXILIARY AIR COMPRESSOR			
31	Piston Rings	1 set	1 set	Rings, of each size used, for one piston.
32	Valves	½ set	½ set	Suction and delivery valves, complete, of each size used.
	ELECTRICAL EQUIPMENT	For items of spare gear to be carried *see* M 21.		
	REFRIGERATING INSTALLATIONS IN SHIPS	For items of spare gear to be carried *see* N 6.		
	BOILERS			
	MAIN AND AUXILIARY BOILERS (*See* G 103)			
33	Tube Stoppers or Plugs	20	10	Tube stoppers or plugs, of each size used, for boiler, superheater and economiser tubes.
34	Fire Bars	1 set	½ set	Fire bars for one boiler, where coal fired.
35	Oil Fuel Burners	1 set	1 set	Oil fuel burners complete, for one boiler.
36	Gauge Glasses	2 sets per boiler	2 sets per boiler	Gauge glasses of round type.
		1 set for every two boilers	1 set for every two boilers	Gauge glasses of flat type.

Chapter M

ELECTRICAL EQUIPMENT AND ELECTRIC PROPELLING MACHINERY

Section 1

GENERAL REQUIREMENTS

101 (*a*) The requirements of this Chapter apply to passenger ships and cargo ships except where otherwise stated. While these requirements are considered to meet those of the 1960 Safety of Life at Sea Convention, attention should be given to any relevant statutory regulations of the National Authority of the country in which the ship is to be registered.

(*b*) In passenger ships services essential for safety are to be maintained under emergency conditions and the safety of ship and personnel from electrical hazards is to be assured.

(*c*) This Chapter states requirements for those features of the electrical installation which are considered essential for the safety of the ship. The design and installation of other equipment is to be such that there is no risk of fire due to its failure. It must, as a minimum, comply with a national or international standard.

(*d*) The Committee will be prepared to give consideration to special cases or to arrangements which are equivalent to the Rules. Consideration will also be given to the electrical arrangements of small ships and ships to be assigned class notations for restricted or special services.

(*e*) Electrical installations for propulsion and auxiliary services are to be constructed and installed in accordance with the relevant sections of this Chapter and are to be inspected and tested by the Surveyors.

Plans

102 The following plans and particulars are to be submitted in triplicate, for consideration :—

PROPULSION EQUIPMENT

Plans of generators, motors and seatings together with diagrams of control gear, cables and circuits, and particulars of voltage, current, power and speed with a key diagram and explanation of the system in relation to the requirements of M 17.

ELECTRIC SLIP COUPLINGS

Plans showing the scantlings and construction of the couplings together with diagrams of electrical components, switchgear and control gear.

ELECTRICAL EQUIPMENT (other than propulsion equipment)

The arrangement plan and circuit diagram of the switchboard(s). Diagrams of the wiring system including cable sizes, type of insulation, normal working current in the circuits and the capacity, type and make of protective devices. Calculations of short circuit currents at main busbars, sub-switchboard busbars and the secondary side of transformers are to be submitted. (*See* M 611.)

WELDING ON SHAFTS

Where welding is to be applied to shafts of machines for essential services for securing armature arms or spiders, plans showing the construction are to be submitted for consideration.

PRIME MOVERS

See G 104.

TANKERS (compartments in between deck spaces)

See M 1605.

CENTRALISED, BRIDGE OR AUTOMATIC CONTROLS

See F 105 and G 111.

Additions or Alterations

103 An addition, temporary or permanent, is not to be made to the approved load of an existing installation until it has been ascertained that the current-carrying capacity and the condition of the existing accessories, conductors and switchgear are adequate for the increased load. (*See* C 108.)

Plans are to be submitted for approval and the alterations or additions are to be carried out under the inspection and to the satisfaction of the Surveyors.

Application

104 Except where a specific statement is made to the contrary all requirements of this Chapter are applicable to both alternating current and direct current installations.

105 D.C. equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent.

A.C. equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent at rated frequency and under frequency fluctuations of plus or minus 2·5 per cent at rated voltage.

Contactors and similar equipment are not to drop out at or above 85 per cent rated voltage.

Ambient Temperatures

106 The following cooling air and cooling water temperatures are applicable in ships classed for :—

(*a*) Unrestricted Service

(i) Primary cooling water supply 30° C. (86° F.)

(ii) Cooling air temperature 45° C. (113° F.)

(*b*) Restricted Service (*See* B 109 and B 110)

Vessels intended solely for use in Northern or Southern waters outside the tropical belt.

(i) Primary cooling water supply 25° C. (77° F.)

(ii) Cooling air temperature 40° C. (104° F.)

Location and Construction

107 Electrical equipment is to be accessibly placed clear of inflammable material in well ventilated, adequately lighted spaces in which inflammable gases cannot accumulate and where it is not exposed to risk of mechanical injury or damage from water, steam or oil. Where necessarily exposed to such risks the equipment is to be suitably constructed or enclosed. Live parts are to be guarded where necessary.

Insulating materials and insulated windings are to be resistant to tracking, moisture, sea air and oil vapour unless special precautions are taken to protect them.

Equipment is not to remain alive through the control circuits and/or pilot lamps when switched off by the control switch. This does not apply to synchronizing switches and/or plugs.

The operation of all electrical equipment and the lubricating arrangements are to be efficient under such conditions of vibration and shock as arise in normal practice, and with the ship inclined from the normal at any angle up to 15 degrees transversely, when pitching 10 degrees longitudinally and when rolling up to 22·5 degrees from the vertical.

All nuts and screws used in connection with current carrying parts and working parts are to be effectively locked.

Conductors and equipment are to be placed at such a distance from the magnetic compasses or are to be so disposed that the interfering magnetic field is negligible even when circuits are switched on and off.

Where electric power is used for propulsion, the equipment is to be arranged so that it will operate satisfactorily in the event of partial flooding by bilge water above the tank top up to floor plate level. (*See* E 223 and E 224.)

Earthing

108 (*a*) Non-current-carrying metal parts of electrical equipment are to be effectively earthed. Where earthing connections are necessary they are to be of copper or other approved material and are to be protected against damage and, where necessary, electrolytic action. In general they are to be equal to the cross section of the current-carrying conductor up to 0·0225 sq. in (16 sq. mm.). Above this figure they are to be equal to at least half the cross section of the current-carrying conductor with a minimum of 0·0225 sq. in. (16 sq. mm.).

(*b*) Portable Equipment—Metal frames of all portable electric lamps, tools and similar apparatus supplied as ship's equipment and rated in excess of 55 V are to be earthed through a suitable conductor unless equivalent safety provisions are made such as by double insulation or by an isolating transformer.

Flameproof and Intrinsically Safe Equipment

109 Where risk of explosion might otherwise arise, equipment is to be of flameproof or intrinsically safe type.

Where equipment is required to be of flameproof or intrinsically safe type and equipment of suitable type is obtainable which has been type tested and approved by a competent independent Testing Authority, it will be sufficient to furnish a copy of the relevant certificate, provided that there is no departure from the design so tested and approved.

NOTE :—

(i) A flameproof enclosure is one which will withstand without injury any explosion of the prescribed flammable gas that may occur within it under practical conditions of operation, and will prevent the transmission of flame such as will ignite the flammable gas in the surrounding atmosphere.

(ii) Intrinsically safe apparatus is to be so constructed that when installed and operated under the conditions specified by the Certifying Authority, any electrical sparking that may occur in normal working, either in the apparatus or in its associated circuit, is incapable of causing an ignition of the prescribed flammable gas or vapour.

Creepage and Clearance

110 The distances between live parts and between live parts and earthed metal whether across surfaces or in air shall be adequate for the working voltage having regard to the nature of the insulating material and the transient over-voltages developed by switch and fault conditions.

For bare busbars the following minimum clearance distances shall be observed.

Voltage between phases or poles	Minimum clearance to earth				Minimum clearance between phases or poles			
	In air		In oil		In air		In oil	
	in.	mm.	in.	mm.	in.	mm.	in.	mm.
660 or less	0·625	16	—	—	0·75	19	—	—
2200	1·5	38	—	—	1·5	38	—	—
3300	2	51	0·5	13	2	51	0·75	19
6600	2·5	63	0·75	19	3·5	89	1·0	25

Where necessary these figures are to be increased to allow for the electro-magnetic forces involved.

Emergency Source of Power

111 An emergency source of power, capable of functioning when the ship is inclined 22·5° and/or when the trim of the ship is 10°, is to be installed in accordance with the following :—

Where emergency generating sets are fitted they are to be capable of being started readily when cold.

If hand starting is demonstrated to be practicable, alternative means of starting are not required. Where hand starting is not practicable other means are to be provided and, in general, should provide for not less than 12 starts in a period of 30 minutes without recourse to sources of power within the machinery space.

I PASSENGER SHIPS

(*a*) A self-contained emergency source of electric power is to be installed above the bulkhead deck and outside the machinery casings. Its location in relation to the main source or sources of electric power is to be such as to ensure that a fire or other casualty to the machinery spaces (i.e. spaces containing the main and auxiliary propelling machinery, boilers serving the needs of propulsion and all permanent coal bunkers) will not interfere with the supply or distribution of emergency power. It is not to be forward of the collision bulkhead.

(*b*) The power available is to be sufficient to supply all services necessary for the safety of passengers and crew in an emergency, due regard being paid to such services as may have to be operated simultaneously. Special consideration is to be given to emergency lighting at every boat station on deck and overside, in all alleyways, stairways and exits, in the machinery spaces and in the control stations (i.e. spaces in which radio, main navigating or central fire recording equipment or the emergency generator is located), to fire detection and alarm systems, to the sprinkler pumps, to navigation lights and to the daylight signalling lamp, if operated from the main source of power. The power is to be adequate for a period of 36 hours, except that, in ships engaged regularly on voyages of short duration a lesser supply will be specially considered.

(*c*) The emergency source of power is to be either :—

(i) A generator driven by a suitable prime mover with an independent fuel supply and with satisfactory starting arrangements; the fuel used is to have a flash point of not less than 43° C. (110° F.); or

(ii) An accumulator (storage) battery capable of carrying the emergency load without recharging or excessive voltage drop.

(*d*) (i) Where the emergency source of power is a generator a temporary source of emergency power is to be installed. This is to be an accumulator battery of sufficient capacity :—

(*a*) To supply emergency lighting continuously for 30 minutes;

(*b*) To close the watertight doors (if electrically operated) but not necessarily to close them simultaneously;

(*c*) To operate the indicators (if electrically operated) which show whether power operated watertight doors are open or closed; and

(*d*) To operate the sound signals (if electrically operated) which give warning that power operated watertight doors are about to close.

(*e*) To operate the fire detection and alarm systems.

Arrangements are to be such that the temporary source of emergency power will come into operation automatically in the event of failure of the main electrical supply.

(ii) Where the emergency source of power is an accumulator battery arrangements are to be such that emergency lighting will automatically come into operation on failure of the main lighting supply.

(*e*) An indicator is to be mounted in the machinery space, preferably on the main switchboard, to indicate when any accumulator battery fitted in accordance with this Rule is being discharged.

(*f*) (i) The emergency switchboard is to be installed as near as is practicable to the emergency source of power.

(ii) Where the emergency source of power is a generator, the emergency switchboard is to be located in the same space as the emergency source of power, unless the operation of the emergency switchboard would thereby be impaired.

(iii) No accumulator battery fitted in accordance with this Rule is to be installed in the same space as the emergency switchboard.

(iv) The emergency switchboard may be supplied from the main switchboard during normal operation.

II CARGO SHIPS

(*a*) A self-contained emergency source of power is to be fitted. This may be either :—

(i) An accumulator (storage) battery capable of carrying the emergency load without recharging or excessive voltage drop; or

(ii) A generator driven by a suitable prime mover with an independent fuel supply and with satisfactory starting arrangements; the fuel used is to have a flash point not less than 43° C. (110° F.).

(*b*) Cargo Ships of 5000T gross tonnage and above

(i) The emergency source of power is to be located above the uppermost continuous deck and outside the machinery casings.

(ii) The power available is to be sufficient to supply all services necessary for the safety of all on board in an emergency.

Special consideration is to be given to :—

(*a*) Emergency lighting at every boat station on deck and oversides, in all alleyways, stairways and exits, in the main machinery space and the main generating set space, on the navigating bridge and in the chartroom.

(*b*) The general alarm.

(*c*) Fire detection and alarm systems.

(*d*) Navigation lights if solely electric and the daylight signalling lamp if operated by the main source of power.

(iii) The power is to be adequate for at least six hours operation.

(*c*) Cargo Ships of less than 5000T gross tonnage

The emergency source of power is to be capable of supplying the illumination at launching stations and stowage positions of survival craft in addition to the emergency lighting, together with the fire detection and alarm systems.

The power available is to be adequate for at least three hours operation.

Section 2

SYSTEMS OF SUPPLY

201 The following systems of distribution may be used :—

(*a*) Parallel systems with constant pressure

Direct Current

Two wire

Three wire with mid-wire earthed.

Alternating Current

Single-phase—two wire

Three phase—

Three wire

Four wire with neutral earthed but without hull return.

Systems employing single wire with hull return may be submitted for special consideration.

(*b*) Series systems with constant current (direct current only).

202 For parallel systems with constant pressure, system voltages for both alternating current and direct current shall not exceed

500 V for generation; power; cooking and heating equipment permanently connected to fixed wiring.

250 V for lighting, heaters in cabins and public rooms and other applications not mentioned above.

203 In very large alternating current installations generation and limited distribution at higher voltages (e.g. 3·3 kV) may be submitted for special consideration. (*See* M 18.)

Section 3

DIVERSITY FACTOR

301 Circuits supplying two or more final subcircuits are to be rated in accordance with the total connected load subject, where justified, to the application of a diversity factor. Where spare ways are provided on a section or distribution board an allowance for future increase of load is to be added to the total connected load before application of any diversity factor.

The diversity factor may be applied to the calculation for size of cable and rating of switchgear and fusegear.

Winch Circuits

302 For winches the diversity factor is to be calculated and submitted.

Section 4

ROTATING MACHINERY

Governors

401 Where a turbine driven direct current generator is arranged to run in parallel with other generators a switch is to be fitted in each turbine emergency governor to open the generator circuit breaker when the emergency governor functions. (*See* H 434).

402 The facilities for adjusting the governor of an alternating current generating set, at normal frequency, are to be sufficiently fine to permit an adjustment of load on the engine within 5 per cent of full load.

Number of Generators

403 The number and ratings of ship's service generating sets and converting sets are to be sufficient to ensure the operation of services essential for the propulsion and safety of the ship and preservation of the cargo even when one generating set or converting set is out of service.

Rating

404 Ships' service generators, including their exciters and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air or water temperature for an unlimited period, without the limits of temperature rise in 405 being exceeded. Other generators and motors are to be rated in accordance with the duty which they are to perform and when tested under rated load conditions the temperature rise is not to exceed the values in 405.

Temperature Rise

405 Ships for Unrestricted Service

Table 4.1 gives the limits of temperature rise above the cooling air temperature for machines not fitted with water coolers and above the cooling water temperature for machines fitted with coolers, for machines intended to operate in ships classed for unrestricted service.

Ships for Restricted Service (*See* M 106)

For machines intended to operate in ships classed for restricted service as defined in M 106 the temperature rises given may be increased by 5° C. (9° F.) for all machines.

If it is known that the temperature of the cooling medium exceeds the values given in M 106 the permissible temperature rise is to be reduced by an amount equal to the excess temperature of the cooling medium.

406 The limits of temperature rise of electric slip couplings are to be in accordance with Table 4.1 except that when a squirrel cage element is used the temperature of this element is not to reach an injurious value. The temperature of the field windings is not to exceed these limits at all speeds of operation. Arrangements for reducing the excitation of self ventilated couplings at low operational speeds are permissible.

407 Alternating current machines of 5000 h.p. or kVA output and above, and propulsion motors having a total axial core length of 1 metre or more are to have at least three embedded temperature

TABLE 4.1

TEMPERATURE RISE IN DEGREES CENTIGRADE

ITEM	PART OF MACHINES	Method of Measurement of Temperature	Temperature-rise °C.					
			Air-cooled machines Class			Water-cooled machines Class		
			A	E	B	A	E	B
1. (a)	A.C. windings of turbine-type machines having output of 5000 kVA or more	ETD or R	50	60	70	70	80	90
(b)	A.C. windings of salient-pole and of induction machines having output of 5000 kVA or more, or having a core length of one metre or more							
2. (a)	A.C. windings of machines smaller than in Item 1...	R	50	65	70	70	85	90
(b)	Field windings of a.c. and d.c. machines having d.c. excitation other than those in Items 3 and 4	T	40	55	60	60	75	80
(c)	Windings of armatures having commutators							
3.	Field windings of turbine-type machines having d.c. excitation...	R	—	—	80	—	—	100
4. (a)	Low-resistance field windings of more than one layer, and compensating windings	T, R	50	65	70	70	85	90
(b)	Single-layer windings with exposed bare surfaces	T, R	55	70	80	75	90	100
5.	Permanently short-circuited insulated windings	T	50	65	70	70	85	90
6.	Permanently short-circuited windings, uninsulated	T	The temperature-rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts					
7.	Iron core and other parts not in contact with windings							
8.	Iron core and other parts in contact with windings	T	50	65	70	70	85	90
9.	Commutators and slip-rings, open or enclosed	T	50	60	70	70	80	90

NOTE 1.— T = Thermometer method
R = Resistance method
E.T.D. = Embedded temperature detector

NOTE 2.—When the commutators, sliprings or bearings of machines provided with water coolers are not in the enclosed air circuit cooled by the water cooler, but are cooled by the ambient cooling air, the permissible temperature-rise above the ambient cooling air should be the same as for ventilated machines.

NOTE 3.—When Class F or Class H insulation is employed the permitted temperature rises are respectively 20° C. and 40° C. higher than the values given for Class B insulation.

NOTE 4.—Classes of insulation are to be in accordance with IEC Publication No. 85 (1957)—Recommendations for the Classification of Material for the Insulation of Electrical Machinery and Apparatus in relation to their thermal stability in service.

detectors. With multi core machines the total length is to be taken as the sum of the individual core lengths.

Overloads

408 Machines are to withstand, on test, without injury the following momentary overloads.

GENERATORS : An excess current of 50 per cent for 15 sec. after attaining the temperature rise corresponding to rated load, the terminal voltage being maintained as near the rated value as possible. The foregoing does not apply to the overload torque capacity of the prime mover.

MOTORS : At rated speed or, in the case of a range of speeds, at the highest and lowest speeds, under gradual increase of torque the appropriate excess torque given below. Synchronous motors and synchronous induction motors are required to withstand the excess torque without falling out of synchronism and without adjustment of the excitation circuit preset at the value corresponding to rated load.

D.C. motors	50% for 15 sec.
Polyphase A.C. synchronous motors	50% for 15 sec.
Polyphase A.C. synchronous induction motors	35% for 15 sec.
Polyphase A.C. induction motors ...	60% for 15 sec.

The overload tests for propulsion machines will be specially considered for each installation.

Short Circuit

409 The stator and rotor windings of alternating current propulsion generators are to be capable of withstanding a momentary short circuit at the terminals of the machine applied when generating full rated voltage. Ship's service generators are to be capable of withstanding the mechanical and thermal effects of fault current for the duration of any time delay which may be fitted in a tripping device for discrimination purposes.

Shaft Currents

410 Means are to be taken to prevent the ill effects of flow of currents circulating between the shaft and bearings.

Welding on Shafts

411 Where welding is applied to shafts of machines for securing armature arms or spiders, stress relieving is to be carried out after welding.

Brushgear

412 The final running position of brushgear is to be clearly and permanently marked.

Direct current motors and generators are to work with fixed brush setting from no load to the momentary overload specified without injurious sparking.

Alternating current commutator motors are to work over the specified range of load and speed without injurious sparking.

Direct Current Service Generators

413 Automatic voltage regulators are to be provided for shunt wound d.c. generators.

414 Direct current generators used for charging batteries without series-regulating resistors are to be either

(i) shunt wound

or (ii) compound wound with switches arranged so that the series winding can be switched out of service.

415 Means are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately.

For each direct current generator, coupled to its prime mover, at any temperature within the working range the means provided is to be capable of adjusting the voltage at any load between no load and full load to within :—

0·5 per cent of rated voltage for generators of rating exceeding 100 kW.

1·0 per cent of rated voltage for generators of rating not exceeding 100 kW.

416 The inherent regulation of ship's service generators is to be such that the following conditions are satisfied :—

For shunt or stabilised shunt wound generators when the voltage has been set at full load, the steady voltage at no load shall not exceed 115 per cent of the full load value, and the voltage obtained at any intermediate value of load shall not exceed the no load value.

For compound wound generators with the generator at full load operating temperature and starting at

20 per cent load with voltage within 1 per cent of rated voltage, then at full load the voltage is to be within 2·5 per cent of rated voltage. The average of the ascending and descending load/voltage curves between 20 per cent load and full load is not to vary more than 4 per cent from rated voltage.

417 Generators are to be capable of delivering continuously the full load current and normal rated voltage at the terminals when running at full load engine speed at all ambient temperatures up to the specified maximum.

418 Generators required to run in parallel are to be stable from no load up to the total combined load of the group and load sharing is to be satisfactory.

419 The series winding of each two-wire generator is to be connected to the negative terminal.

420 Equaliser connections are to have a cross sectional area appropriate to the system but in no case less than 50 per cent of that of the negative connection from the generator to the switchboard.

Alternating Current Service Generators

421 Each alternating current service generator, unless of the self-regulated type, is to be operated in conjunction with a separate automatic voltage regulator.

422 The voltage regulation of any alternating current generator with its AVR is to be such that at all loads from zero to full load the rated voltage at rated power factor is maintained under steady conditions within $\pm 2{\cdot}5$ per cent.

423 In alternating current systems with one generator set out of action, the remaining set(s) are to have sufficient reserve capacity to permit the starting of the largest motor in the ship without causing any motor to stall or any other device to fail due to excessive voltage drop on the system.

424 Alternating current generators required to run in parallel are to be stable from 20 per cent full load (kW) up to the total combined full load (kW) of the group and load sharing is to be satisfactory.

425 When generators are operated in parallel the kVA loads of the individual generating sets are not to differ from their proportionate share of the total kVA load by more than 5 per cent of the rated kVA output of the largest machine when operating at 0·8 power factor.

Inspection and Testing

426 On machines for essential services tests are to be carried out and a certificate furnished by the manufacturer. The tests are to include temperature rise, momentary overload, high voltage, and commutation. The insulation resistance and the temperature at which it was measured shall be recorded. Shaft materials are to comply with Chapter P.

Generators of 100 kW or over and motors of 100 h.p. and over intended for essential services are to be inspected by the Surveyors during manufacture and testing. (A list of essential services is given in M 2102.) Shaft materials are to be tested in accordance with P 6.

427 In the case of duplicate machines up to 50 kW, kVA or b.h.p. per 1000 r.p.m. type tests of temperature rise, excess current and torque and commutation taken on a machine identical in rating and in all other essential details may be accepted in conjunction with abbreviated tests on each machine. This is not to apply to propulsion machines. For the abbreviated tests, each machine is to be run and is to be found electrically and mechanically sound and is to have a high voltage test and insulation resistance recorded.

High Voltage Test

428 A high voltage test of 1000 V plus 2 × rated voltage with a minimum of 2000 V is to be applied to new machines preferably at the conclusion of the temperature rise test. The test is to be applied between the windings and the frame with the core connected to the frame and to any windings (or sections of windings) not under test. Where both ends of each phase are brought out to accessible separate terminals each phase is to be tested separately. The test is to be made with alternating voltage at any convenient frequency between 25 and 100 cycles per second of approximately sine wave form. The test is to be commenced at a voltage of about one-third the test voltage and is to be increased to full value as rapidly as is consistent with its value being indicated by the measuring instrument. The full test voltage is then to be maintained for one minute, and then reduced to one-third full value before switching off.

When it is desired to make additional high voltage tests on a machine which has already passed its tests the voltage of such additional tests is to be 75 per cent of the figure given above.

Motors for Refrigerated Cargo Services

429 Motors intended for coupling to fans for the circulation of air in refrigerated cargo spaces are to be inspected by the Surveyors during manufacture and testing.

Plans showing the construction of the motors are to be submitted for consideration.

Fan motors fitted in the air stream are to be totally enclosed or otherwise suitably enclosed to withstand the effects of excessive moisture where they are fitted between the two sections of a cooler or where the air from the cooler passes over the motor.

The Surveyors will witness a type test on the first motor of each size and type and works test certificates are to be supplied for the remainder. This type test may also be accepted for repeat orders of motors identical in all essential respects provided cross references are given in the works test certificates. Type tests need not be carried out for motors of the same frame size as one previously tested for higher output.

Where motors are mounted in the air stream but are to be tested in still air conditions generally two conditions arise :—

(i) The motor may be open at one end or both ends when tested but totally enclosed when mounted in the air stream. In such cases a type test should be carried out under working conditions, i.e., in the trunking with the fan and fairings in place or alternatively, calculations furnished to show that the Rules for temperature rise are complied with.

(ii) The motor may be totally enclosed but with streamlined fairings. These may be accepted if, when tested in still air, the temperature rises are within the requirements of the Rules for totally enclosed motors. If they are outside these requirements the procedure in (i) is to be followed.

Electric Slip Couplings

430 Slip couplings are to be inspected by the Surveyors during manufacture and testing. Unless otherwise approved, every coupling is to be tested at the makers' works, the tests to include :—

Temperature rise test

High voltage test

Insulation resistance is to be recorded, together with the temperature at which it was measured.

Section 5

DISTRIBUTION

Final Sub-Circuits

501 A final sub-circuit of rating exceeding 15A is not to supply more than one point. The number of lighting points supplied by a final sub-circuit of rating 15A or less is not to exceed :—

for	24 — 55 V	circuits	10
„	110 — 127 V	„	14
„	220 — 250 V	„	18

except that in final sub-circuits for cornice lighting, panel lighting and electric signs where lampholders are closely grouped the number of points supplied is unrestricted provided the maximum operating current in the sub-circuit does not exceed 10A.

502 A separate final sub-circuit is to be provided for every motor required for essential services.

503 Lighting circuits are to be supplied by final sub-circuits separate from those for heating and power. (This does not apply to cabin fans and wardrobe heaters.)

504 Lighting of cargo spaces and coal bunkers is to be controlled by multi-pole linked switches situated outside these spaces. Provision is to be made for the complete isolation of these circuits and locking in the off position of the means of control.

Navigation Lights

505 Navigation lights are to be connected separately to a distribution board reserved for this purpose only, and connected directly or through transformers to the main or emergency switchboard. The distribution board is to be accessible to the officer of the watch.

Each navigation light is to be controlled and protected in each insulated pole by a switch and fuse or circuit breaker mounted on the distribution board.

Where the navigation panel is situated in the midships house, the midships sub-switchboard is regarded as an extension of the main switchboard providing it is supplied from the main switchboard by two cables each capable of carrying full load.

Each navigation light is to be provided with an automatic indicator giving aural and/or visual indication of failure of the light. If an aural device alone

is fitted it is to be connected to a primary or secondary battery. If a visual signal is used connected in series with the navigation light means are to be provided to prevent extinction of the navigation light due to failure of the signal. The requirements of this paragraph do not apply to tugs, trawlers, fishing and similar small vessels.

Provision is to be made on the bridge for such navigation lights to be transferred to an alternative circuit.

Any statutory requirements of the country of registration are to be complied with and may be accepted as an alternative to the above.

Steering Gear

506 (*a*) Only short circuit protection and overload alarm are to be provided in steering gear circuits.

(*b*) Indicators for running indication of steering gear motors are to be installed.

The exact position of the rudder, if power operated, is to be indicated at the principal steering station.

(*c*) In all passenger ships and in cargo ships of 5000T gross tonnage and upwards electric and electro-hydraulic steering gear is to be served by two circuits fed from the main switchboard. One of the circuits may pass through the emergency switchboard. Each circuit is to have adequate capacity for supplying all the motors which are normally connected to it and which operate simultaneously.

If transfer arrangements are fitted in the steering gear room to permit either circuit to supply any motor or combination of motors, the capacity of each circuit is to be adequate for the most severe load conditions.

The circuits are to be separated throughout their length as widely as is practicable.

(*d*) In cargo ships of less than 5000T gross tonnage where electric power is the sole source of power for both main and auxiliary steering gear the supply arrangements are to comply with (*c*) above.

If the auxiliary steering gear is powered by a motor primarily intended for other services alternative protective arrangements to that required by sub-para. (*a*) will be specially considered.

(*e*) Where electric control of the steering system is fitted an alternative control system is to be installed. This may be a duplicate electrical control system or control by other means.

Fire Detection, Alarm and Extinguishing Systems

507 (*a*) Where electrically driven emergency fire pumps are installed in accordance with F 403 and F 505, the supply to such pumps is not to pass through the main machinery spaces.

(*b*) Any fire alarm system is to operate both audible and visual signals at the fire detection control station(s). Detection systems for cargo spaces need not have audible alarms.

(*c*) Electrical equipment used in operating fire detecting equipment is to have two sources of electrical power, one of which is to be the emergency source. (*See* M 111 and F 105 with Footnote).

In addition, the following apply to passenger ships :—

(*d*) Where automatic sprinkler systems are fitted and electrical power is used for the operation of sea water pumps, air compressors and alarms fitted in conjunction with such systems at least two sources of power are to be arranged. The sources of power are to be a main generator and the emergency source of power. (*See* M 111.) One supply is to be taken from the main switchboard by separate feeders reserved solely for this purpose. Such feeders are to be run to a change-over switch situated near the sprinkler unit and the switch is to be normally closed to the feeder from the emergency switchboard. The change-over switch is to be clearly labelled and no other switch other than those at the switchboard(s) is permitted in these feeders.

In passenger ships with aluminium superstructures where feeders from the emergency generator to the sprinkler unit pass through any space constituting a fire risk the cables are to be of fireproof type.

Heating and Cooking

508 Each item of heating or cooking equipment is to be controlled as a complete unit by a multi-pole linked switch mounted in the vicinity of the equipment. In the case of cabin heaters a single pole switch will be acceptable.

Shore Supply

509 (*a*) Where arrangements are made for the supply of electricity form a source on shore or elsewhere a suitable connection box is to be installed in a

position in the ship suitable for the convenient reception of flexible cables from the external source and containing a circuit breaker or isolating switch and fuses and terminals of ample size and suitable shape to facilitate a satisfactory connection. Suitable cables, permanently fixed, are to be provided, connecting the terminals to a linked switch and/or a circuit breaker at the main switchboard.

(*b*) For three-phase shore supplies with earthed neutral an earth terminal is to be provided for connecting the hull to the shore earth.

(*c*) The shore connection is to be provided with an indicator at the main switchboard in order to show when the cable is energised.

(*d*) Means are to be provided for checking the polarity (for direct current) or the phase sequence (for three-phase alternating current) of the incoming supply in relation to the ship's system.

(*e*) At the connection box a notice is to be provided giving full information on the system of supply and the normal voltage (and frequency if alternating current) of the ship's system and the procedure for carrying out the connection.

(*f*) Alternative arrangements may be submitted for consideration.

Submersible Bilge Pumps

510 Motors of permanently installed submersible bilge pumps are to be connected to the emergency switchboard (if fitted).

Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cables are to be suitable for operation in permanently wet situations, and installed in continuous lengths from above the bulkhead deck to the motor terminals.

Under all circumstances it is to be possible to start the motor of a permanently installed submersible bilge pump from a position above the bulkhead deck.

Section 6

SWITCHBOARDS, SWITCHGEAR AND PROTECTIVE EQUIPMENT

Switchboards

601 (*a*) An unobstructed space is to be left in front of switchboards. Pipes should, as far as possible, not be installed directly above or in front of or behind switchboards. If such placing is unavoidable suitable protection is to be provided in these positions. (*See* E 275).

(*b*) Where necessary the space at the rear of switchboards is to be ample to permit maintenance and in general not less than 24 in. (0,6 m.) except that this may be reduced to 18 in. (0,5 m.) in way of stiffeners or frames.

(*c*) For voltages between poles or to earth above 55 V a.c. or 250 V d.c. dead front switchboards are to be used. Where live parts on a switchboard are adjacent to a gangway an insulated handrail is to be provided and non-conducting mats or gratings are to be fitted at front and rear of the switchboard as necessary.

(*d*) Section and distribution boards are to be suitably enclosed unless they are installed in a cupboard or compartment to which only authorised persons have access, in which case the cupboard may serve as the enclosure.

All enclosures are to be constructed of, or lined with, non-flammable and non-hygroscopic material and are to be of robust construction.

(*e*) All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly labelled for identification purposes. An indelible label is to be permanently secured to, or adjacent to, every fuse and every circuit breaker and marked with particulars of the full load current of the generator or cable which the fuse or circuit breaker protects. The labels for rewirable fuses are also to be marked with the appropriate size of fuse element. Where inverse time limit and/or reverse current devices are provided in connection with a circuit breaker, the appropriate settings of these devices are to be stated on the label. Nameplates are to be of flame-retardant material.

(*f*) In a passenger ship where there is only one main generating station the main switchboard is to be located in the same fire zone. Where there is more than one main generating station it is permissible to have only one main switchboard.

Busbars

602 Busbars and their connections are to be of copper, all connections being made so as to inhibit corrosion. Busbars and their supports are to be so designed as to withstand the mechanical stresses which will arise during short circuits. The maximum permissible temperature rise for bare conductors is 45° C. (81° F.).

Equaliser Connections

603 The current rating of equaliser connections and equaliser switches is to be not less than half the rated full load current of the generator. The current rating of equaliser busbars is to be not less than half the rated full load current of the largest generator in the group.

Instruments for Direct Current Generators

604 (*a*) For generators not operated in parallel at least one voltmeter and one ammeter are to be provided for each generator.

(*b*) For parallel operation one ammeter is to be provided for each generator, and two voltmeters. One voltmeter is to be connected to the busbars and the other is to be capable of measuring the voltage of any generator.

(*c*) For compound wound generators fitted with equaliser connections the ammeter is to be connected to the pole opposite to that connected to the series winding of the generator.

(*d*) For three-wire generators the ammeter is to be located between the equaliser connection and the generator.

(*e*) For three-wire systems supplied by a three-wire generator or by a balancing booster an ammeter is to be connected to each outer pole of each balancing generator and a voltmeter between each pole of the busbars and the middle wire.

Instruments for Alternating Current Generators

605 (*a*) For alternating current generators not operated in parallel each generator is to be provided with at least one voltmeter, one frequency meter and one ammeter with an ammeter switch to enable the current in each phase to be read or an ammeter in each phase and for generators above 50 kVA a wattmeter.

(*b*) For alternating current generators operated in parallel each generator is to be provided with a wattmeter, and an ammeter in each phase conductor or an ammeter with a selector switch to permit the measuring of current in each phase.

For paralleling purposes two voltmeters, two frequency meters and a synchronising device comprising either a synchroscope and lamps, or an equivalent arrangement, are to be provided. One voltmeter and one frequency meter are to be connected to the busbars, the other voltmeter and frequency meter are to be switched to enable the voltage and frequency of any generator to be measured.

Instrument Scales

606 (*a*) The upper limit of the scale of every voltmeter is to be approximately 120 per cent of the normal voltage of the circuit and the normal voltage is to be clearly indicated.

(*b*) The upper limit of the scale of every ammeter is to be approximately 130 per cent of the normal rating of the circuit in which it is installed. Normal full load is to be clearly indicated.

(*c*) Ammeters for use with direct current generators and kW meters for use with alternating current generators which may be operated in parallel are to be capable of indicating 15 per cent reverse current or power respectively.

Instrument Transformers

607 The secondary windings of instrument transformers are to be earthed.

Earth Indication

608 Every insulated distribution system is to be provided with lamps or other means to indicate the state of insulation from earth.

Protection

609 Installations are to be protected against accidental overcurrents including short-circuit. The protective devices are to provide complete and co-ordinated protection to ensure :—

(i) Continuity of service under fault conditions through discriminative action of the protective devices.

(ii) Elimination of the fault so as to reduce damage to the system and hazard of fire.

Protection against Overload

610 Circuit-breakers and automatic switches provided for overload protection are to have tripping characteristics appropriate to the system. Fuses above 320A are not to be used for overload protection, but may be used for short-circuit protection.

Over-current releases of circuit-breakers for generators and for circuits with preference tripping are to be adjustable.

NOTE.—Overload is considered to be an over-current in a circuit in which the insulation is still effective. Short circuit is considered to be an over-current in a circuit in which the insulation is defective.

Protection against Short Circuit

611 Protection against short-circuit currents is to be provided by circuit-breakers or fuses.

The breaking capacity of every protective device is to be not less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.

The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short-circuit, is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

Every protective device or contactor not intended for short-circuit interruption is to be adequate for the maximum short-circuit current which can occur at the point of installation having regard to the time required for the short-circuit to be removed.

In the absence of precise data the following short-circuit currents at the machine terminals are to be assumed :—

D.C. Systems

Ten times full load current for generators normally connected (including spare).

Six times full load current for motors simultaneously in service.

A.C. Systems

Ten times full load current for generators normally connected (including spare)—symmetrical RMS.

Three times full load current for motors simultaneously in service.

Combined Circuit-Breakers and Fuses

612 The use of a circuit-breaker of breaking capacity less than the prospective short-circuit current at the point of installation is permitted provided that it is preceded on the generator side by fuses, or by a circuit-breaker having at least the necessary breaking capacity. The generator breakers are not to be used for this purpose.

Fused circuit-breakers with uses connected to the load side may be used where operation of the circuit-breaker and fuses is co-ordinated.

The characteristics of the arrangement shall be such that :—

(i) When the short-circuit current is broken the circuit-breaker on the load side shall not be damaged and is to be capable of further service.

(ii) When the circuit-breaker is closed on the short-circuit current the remainder of the installation shall not be damaged. It is, however, admissible that the circuit-breaker on the load side may require servicing after the fault has been cleared.

Protection of Circuits

613 Short-circuit protection is to be provided in each live pole of a direct-current system and in each phase of an alternating-current system.

Overload protection is to be provided in :—

Two-wire d.c. or single-phase a.c. system—at least one line or phase.

Three-wire d.c. system—both outer lines.

Insulated three-phase a.c. system—at least two phases.

Earthed three-phase a.c. system—all three phases.

No fuse, non-linked switch or non-linked circuit-breaker is to be inserted in an earthed conductor. Any switch or circuit-breaker fitted is to operate simultaneously in the earthed conductor and the insulated conductors.

These requirements do not preclude the provision (for test purposes) of an isolating link to be used only when the other conductors are isolated.

Protection of Generators

614 In addition to over-current protection the following protective gear is to be provided as a minimum :—

(*a*) For generators not arranged to run in parallel : A circuit-breaker arranged to open simultaneously all insulated poles or in the case of generators rated at less than 50 kW a multi-pole-linked switch with a fuse in each insulated pole.

(*b*) For generators arranged to operate in parallel : A circuit-breaker arranged to open simultaneously all insulated poles. This circuit-breaker is to be provided with :—

(i) For direct-current generators, instantaneous reverse-current protection operating at not more than 15 per cent rated current.

(ii) For alternating-current generators a reverse-power protection, with time delay, selected and set within the limits of 2 per cent to 15 per cent of full load to a value fixed in accordance with the characteristics of the prime mover.

The reverse-current protection is to be adequate to deal with the reverse-current conditions emanating from the ship's network, e.g., cargo winches. The reverse-power protection specified for alternating current generators may be replaced by other devices ensuring adequate protection of the prime movers.

(*c*) In addition the following is to be provided for direct-current generators arranged to operate in parallel.

(i) Where an equaliser connection is in use the reverse-current protection is to be provided in the pole opposite to that in which the series winding is connected.

(ii) For compound generators an equaliser switch for each generator so interlocked that it closes before and opens after the main contacts of the circuit-breaker with which it is associated, or a three-pole circuit-breaker with all poles operating simultaneously.

(iii) In three-wire systems a switch in the connection to the middle wire so interlocked with the generator switch or circuit-breaker connected to the outers as to operate simultaneously with them.

Essential Services

615 Where generators are operated in parallel and essential machinery is electrically driven arrangements are to be made to disconnect automatically the excess non-essential load when the generators are overloaded.

If required this load shedding may be carried out in one or more stages.

Circuits for cargo refrigeration machinery are to be included in the last group to be disconnected.

Power Transformers

616 The primary circuits of power transformers are to be protected against short-circuit by circuit-breakers or fuses.

When transformers are arranged to operate in parallel, means of isolation are to be provided on the secondary windings. Switches and circuit-breakers are to be capable of withstanding surge currents.

Feeder Circuits

617 Isolation and protection of each main distribution circuit is to be ensured by a multi-pole circuit breaker or switch and fuses. Protection is to be in accordance with 610, 611 and 613 except that steering gear circuits are to have short-circuit protection only and overload alarm. The protective devices are to allow excess current to pass during the normal accelerating period of motors.

Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

Motors of rating exceeding 0·5 kW/h.p. and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection can be provided by the same protective device for the motor and its supply cable. For essential motors which are duplicated the overload protection may be replaced by an overload alarm if desired by the owner.

For motors intended to provide uninterrupted service the protective gear is to have a delay characteristic to enable the motor to start, yet which will operate on overload before the windings reach an unacceptably high temperature. The current which the protective device will allow to pass indefinitely is not to exceed 125 per cent of the rated current.

For motors for intermittent service the current setting and the delay are to be chosen in relation to the load factor of the motor.

Lighting circuits are to be provided with overload and short-circuit protection.

Meters, Pilot Lamps, Capacitors

618 Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps together with their connecting leads.

A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided it is fitted in the same enclosure. Where a fault in a pilot lamp would jeopardise the supply to essential equipment such lamps are to be individually protected.

Where capacitors for suppression of radio interference are fitted to busbars, generators, or steering-gear, fuses of appropriate size are to be connected in the capacitor circuit.

Switchgear

619 (*a*) Circuit-breakers and switches are to be of the air break type.

(*b*) The limits of temperature rise are to be based on the cooling air temperatures given in Section 1, and when measured by thermometer or thermocouple are not to exceed :—

Contacts : Solid copper ...	40° C.	(72° F.)
Silver or similar	65° C.	(117° F.)
Bare conductors and connections	45° C.	(81° F.)

Coils: Class A insulation ...	50° C.	(90° F.)
Class E insulation ...	65° C.	(117° F.)
Class B insulation ...	80° C.	(144° F.)

(*c*) Reports of tests to establish the capacity of circuit-breakers are to be submitted for consideration when required.

(*d*) Each circuit opening device is to be so arranged that when placed in the OFF position it cannot accidentally move so as to close the circuit.

(*e*) Circuit-breakers are to be of the trip free type.

(*f*) The over-current releases of circuit-breakers for generators and the setting of preference tripping relays are to be adjustable, or if of the non-adjustable type are to be readily replaceable by others of different values.

(*g*) Where reverse-power or reverse-current protection is provided it is to be appropriate to the circumstances of reverse-power between the limits of 2 per cent and 15 per cent of full load that may be expected. (*See* 614(b).)

(*h*) A fall of 50 per cent in the applied voltage shall not render the reverse-current mechanism inoperative although it may alter the amount of reverse-current required to open the breaker.

(*i*) Over-current releases are to be calibrated in amperes, and the settings marked on the circuit-breaker.

(*j*) Handles and operating mechanisms are to be so arranged that the hand of the operator cannot accidentally touch live metal or be injured through an arc arising from the switch or circuit breaker, or the rupturing of a fuse. If switches are enclosed their handles are not to operate through unprotected slots.

Testing

620 Before installation, switchboards complete or in sections with all components are to pass the following tests at the manufacturers' works and a certificate furnished. A high voltage test is to be carried out on all switching and control apparatus for systems greater than 60 V with a test voltage of 1000 V plus twice the rated voltage (minimum 2000 V) at any frequency between 25 c/s and 100 c/s for one minute applied between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase.

For systems of 60 V or less the test shall be at 500 V for one minute.

Immediately after the high voltage test the insulation resistance between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase, shall be not less than 1 megohm when tested with a d.c. voltage of at least 500 V.

Instruments and ancillary apparatus may be disconnected during the high voltage test.

Fuses

621 Fuses are to comply with an approved national standard or with the recommendations of the International Electrotechnical Commission and with the following clauses.

The breaking capacity of the fuse is to be not less than the prospective short-circuit current at the point of installation.

Fuses are to be suitable for operating in the ambient temperatures given in M 106 and the temperature rise at the terminals is to be such that the maximum permissible temperature(s) of the connected cable(s) is not exceeded.

622 Fuse-links and fuse-bases are to be marked with particulars of rated current and rated voltage. Each fuse position is to be permanently and indelibly labelled with the current-carrying capacity of the circuit protected by it and with the appropriate approved size of fuse or replaceable element.

623 A list of approved fuses will be issued. To secure approval a report, preferably by an independent authority, is to be submitted giving details of test performance, fusing characteristics, temperature and insulation tests and details of the specification to which the fuse had been tested. Outline drawings are to be included but samples should not be submitted unless requested.

Section 7

CONTROL GEAR

701 The limits of temperature rise for control gear are to be based on the cooling air temperatures given in M 106.

The temperature rise, at full rated load, measured by thermometer or thermocouple is not to exceed:—

Contacts: Solid copper ...	60° C.	(108° F.)
Silver or similar ...	75° C.	(135° F.)
Bare conductors and connections	45° C.	(81° F.)
Coils: Class A insulation ...	60° C.	(108° F.)
Class E insulation ...	75° C.	(135° F.)
Class B insulation ...	90° C.	(162° F.)

Resistors—maximum operating temperatures shall not exceed 410° C. (770° F.).

Other parts whether insulated or not are not to reach a temperature which might harm the parts themselves or materials with which they are in contact.

702 Control gear, including isolating and reversing switches is to be so arranged that shunt field circuits are not disconnected without an adequate discharge path being provided.

703 Every electric motor is to be provided with efficient means of starting and stopping so placed as to be easily operated by the person controlling the motor. Every motor above 0·5 kW/h.p. is to be provided with the following control apparatus:—

(*a*) Means to prevent undesired restarting after a stoppage due to low volts or complete loss of volts. This does not apply to motors, the continuous availability of which is essential to the safety of the ship.

(*b*) Efficient means of isolation are to be provided so that all voltage may be cut off from the motor and any associated apparatus including any automatic circuit-breaker.

Where the primary means of isolation (that provided at the switchboard, section board or distribution fuse board) is remote from a motor, one of the following is to be provided:—

(i) An additional means of isolation fitted adjacent to the motor.

or (ii) Provision made for locking the primary means of isolation in the OFF position.

or (iii) Provision made so that the fuses in each line can be readily removed and retained by authorised personnel.

(*c*) Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor (this does not apply to steering motors). (*See also* M 617.)

(*d*) Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

704 When selecting motor control gear the maximum current of a motor is to be taken as the full load rated current of the motor.

705 Where a single master-starter system (e.g., a starter used for controlling a number of motors successively) is used the apparatus is to provide under-voltage and over-current protection and means of isolation for each motor not less effective than that required for systems using a separate starter for each motor. Where the starter is of the automatic type, suitable alternative means are to be provided for manual operation. Where the starter is used for motors for essential services the starting portion shall be duplicated and means are to be provided for the transfer of the starting duties in the event of failure of one of the starters.

706 Means are to be provided for stopping ventilating fans serving machinery and cargo spaces. These means are to be capable of being operated from outside such spaces in case of fire.

Machinery driving forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pump and other similar fuel pumps are to be fitted with remote controls situated outside the space concerned so that they may be stopped in the event of fire arising in the space in which they are located.

In passenger ships carrying more than 36 passengers all power ventilation systems, except cargo and machinery space ventilation, which is to be in accordance with the first sub-paragraph, are to be fitted with master controls so that all fans may be stopped from either of two separate positions which are to be situated as far apart as practicable.

707 Control gear and resistors are to be tested by the makers with a high voltage applied between the earthed frame and all live parts. The test voltage is to be 1000 V plus twice the rated voltage with a minimum of 2000 V. The voltage is to be alternating at any frequency between 25 and 100 c/s and is to be maintained for one minute without failure.

Immediately after the high voltage test the insulation resistance between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase, shall be not less than 1 megohm when tested with a direct current voltage of at least 500 V. Instruments and auxiliary apparatus may be disconnected during the high voltage test.

Section 8

CABLES

Conductors

801 High conductivity annealed copper only is to be used. For rubber-insulated cables the copper wire is to be tinned or alloy coated and the surface is to be bright.

Conductor composition and stranding is to be selected so that adequate flexibility of the finished cable is assured. Conductors of nominal cross section 0·003 sq. in. (2,5 sq. mm.) and less need not be stranded. This requirement does not apply to mineral-insulated cables which have solid conductors. Cores of multi-core cables are to be readily identifiable.

Insulating Materials

802 The following insulating materials are permitted:—

TABLE 8.1

Insulating Material	Maximum rated conductor Temp. °C.	Maximum Ambient Temp. °C.
Natural or synthetic rubber (general purpose)	60	50
Polyvinyl chloride compound (general purpose)	60	50
Natural or synthetic rubber (heat resisting)	75	65
Varnished cambric, Butyl ...	80	70
Asbestos-varnished cambric ...	85	75
Silicone rubber	95	—
Mineral...	95	—

NOTE.—Silicone rubber and mineral insulation may be used for higher temperatures when installed where they are not liable to be touched by ship's personnel viz. silicone rubber 150° C. mineral unlimited. Proposals to employ these higher temperatures will be specially considered.

Where a rubber or rubber-like material with maximum conductor temperature greater than 60° C. is used it is to be readily identifiable.

Other insulating materials will be considered.

Insulation

803 (*a*) RUBBER—The use of a single layer is permitted only when applied by the extrusion process. With other processes the insulation is to consist of at least two layers of rubber compound equal or different in quality (including polychloroprene compound but not pure rubber). The layers are to be bonded together.

The insulating wall is to be close fitting, but not adherent to the conductor.

(*b*) POLYVINYLCHLORIDE—Polyvinylchloride insulation is to be applied by extrusion in one or more layers, is to be close fitting but not adherent to the conductor.

(*c*) VARNISHED CAMBRIC—Varnished cambric is to consist of a closely woven cloth tape uniformly coated on both sides with an insulating varnish. The average thickness of the finished cloth is to be not less than 5 mils (0,13 mm.) nor more than 13 mils (0,33 mm.).

The insulating wall is to consist of several layers of varnished cambric tape, applied helically and smoothly, with or without overlapping, each tape covering the gap, if any, of the underlying tape.

An insulating and lubricating compound is to be applied between the layers of varnished cloth so as to exclude air and moisture.

If a binder or identification tape is used and is made of insulating material it may be considered as part of the insulating wall.

(*d*) ASBESTOS-VARNISHED CAMBRIC—The insulation of each conductor is to consist of a layer of felted asbestos, impregnated with heat and moisture resisting compound, plus layers of varnished cambric tape plus a layer of impregnated-felted asbestos. In place of felted asbestos, asbestos roving, glass roving, asbestos tape or glass tape may be used.

(*e*) MINERAL INSULATION—Mineral insulation is to consist of a powdered mineral material, e.g. magnesium oxide, highly compressed between conductors and copper sheath. It is to be temperature-stable and non-corrosive to copper.

Construction

804 Whatever the insulating material used both the belted and non-belted construction may be used for two, three and more conductor cables.

Non-belted Cables

805 For non-belted cables the spaces among the cores are to be filled with fibrous or rubber-like fillers and the cylindrical assembly is to be sheathed with the appropriate protective covering. Fillers may be omitted in multi-core cables having conductor sections 0·007 sq. in. (4,5 sq. mm.) or less.

Belted Cables

806 Belted cables are to be constructed as non-belted cables except that an insulating wall is to be applied to the cabled cores before applying the protective covering. For rubber or PVC-insulated cables the common belt is to be rubber or PVC respectively which may or may not form one body with the fillers.

Fillers

807 When fibrous fillers are used they are to consist of jute or similar rovings (including asbestos, glass, &c.), and are to be resistant to moisture.

When rubber-like fillers are used they are to consist of rubber (including regenerated and/or unvulcanized rubber) compounds or plastic compounds.

Sheaths and Protective Coverings

808 Cables are to be protected by one or more of the following and the sheath or protective covering is to be compatible with the insulation :—

Sheath	Lead-alloy sheath
	Copper sheath
	Non-metallic sheath
Protective Covering	Steel-wire armour
	Steel-tape armour
	Metal-braid armour (basket weave)
	Fibrous braid

Unsheathed cables, e.g., rubber-insulated taped and braided or equivalent may be used only if installed in conduit.

(*a*) Lead-Alloy Sheath—This is to be one of the recommended lead alloys given in I.E.C. Publication 92.

(*b*) Copper—Copper sheath is permitted only for mineral-insulated cables.

(*c*) Metal-Braid Armour (Basket weave)—This is to be formed of galvanized steel, copper or copper alloy or aluminium alloy wires. Aluminium alloy is to be corrosion-resistant. The coverage density of the braid is to be such that the weight of the braid is at least 90 per cent of the weight of a tube of the same metal having an internal diameter equal to the internal diameter of the braid and a thickness equal to the diameter of one of the wires forming the braid.

(*d*) Steel-Wire Armour—This is to consist of galvanized-annealed-steel wires having an elongation at break of at least 12 per cent. The wires are to be applied over the bedding so as to form a uniformly cylindrical layer and so as to ensure adequate flexibility of the cable.

(*e*) Steel-Tape Armour—This is to consist of annealed-steel tape. In general, the armour is to be formed of two tapes wound over the bedding in the same direction so that the gap in the first layer is not more than half the tape width and the second layer covers this gap with an overlap.

Note—Armour is to be protected against corrosion where necessary. A protective bedding is to be inserted beneath armour (of any type). This may be textile tape or braid, PCP tape or other suitable material. Textile materials are to be treated against moisture.

(*f*) Non-Metallic Sheath—Polychloroprene compound and polyvinylchloride compound may be used for impervious sheaths. For asbestos varnished cambric cables, asbestos sheath is permissible.

(*g*) Fibrous Braid—Textile braid is to be of cotton, hemp, asbestos, glass, or other equivalent fibre and is to be of strength suitable for the size of the cable. It is to be effectively impregnated with a compound which is resistant to moisture, and flame retarding except where flame-extending cables are permitted by 812.

Dimensions

809 The thickness of insulation and sheath is to be generally in accordance with Tables 8.2 and 8.3.

The cables may be used in circuits in which the voltage between a conductor and the hull of the ship does not exceed the voltage at the head of the appropriate Table. In an insulated system the voltage between any conductor and the hull of the ship is assumed to be equal to the voltage between lines.

250 V cables may be used for any conductor of a three-phase, 440 V, alternating-current system with star point earthed.

Cables with other dimensions but which comply with a national specification for marine cables may be submitted for consideration.

Choice of Cables

810 The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

Cables exposed to voltage surges associated with highly inductive circuits, e.g., contactor operating circuits for winches, etc., are to be at least 500 V grade.

The rated operating temperature of the insulating material is to be at least 10° C. (18° F.) higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

Where polyvinylchloride insulation is employed, particular care should be taken to avoid damage to the sheathing during the fitting of watertight bulkhead glands.

TABLE 8.2

THICKNESS OF INSULATION

Nominal cross section			Rubber and Rubberlike		P.V.C.		Varnished Cambric			Asbestos-Varnished Cambric				Mineral	
			250 V.	660 V.	250 V.	660 V.	1100 V.		3300 V.	250 V.		660 V.		440 V.	660 V.
			Radial	Radial	Radial	Radial	c/c	c/s	c/c; c/s	Radial Cambric	Radial Asbestos	Radial Cambric	Radial Asbestos	c/c; c/s	c/c; c/s
	sq. in.	sq. mm.	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*
1/·044	·0015		·030	·055	·025	·035				·018	·020	·030	·030	·040	·060
		1	*0,8*	*1,4*	*0,6*	*0,9*				*0,45*	*0,5*	*0,8*	*0,8*	*1,0*	*1,5*
3/·029	·002		·030	·055	·025	·035				·018	·020	·030	·030	·040	·060
		1,5	*0,8*	*1,4*	*0,6*	*0,9*				*0,45*	*0,5*	*0,8*	*0,8*	*1,0*	*1,5*
3/·036; 1/·064	·003		·030	·055	·025	·035				·018	·020	·030	·030	·040	·060
		2,5	*0,8*	*1,4*	*0,6*	*0,9*				*0,45*	*0,5*	*0,8*	*0,8*	*1,0*	*1,5*
7/·029	·0045		·030	·055	·025	·035	·070	·055		·018	·020	·030	·030	·040	·060
		4	*0,9*	*1,5*	*0,6*	*1,0*	*1,8*	*1,4*		*0,45*	*0,5*	*0,8*	*0,8*	*1,0*	*1,5*
7/·036	·007		·035	·060	·030	·040	·070	·055		·018	·020	·030	·030	·040	·060
		6	*0,9*	*1,5*	*0,8*	*1,0*	*1,8*	*1,4*		*0,45*	*0,5*	*0,8*	*0,8*		*1,5*
7/·044	·01		·035	·060	·030	·040	·070	·055		·018	·020	·030	·030		·060
7/·052	·0145		·040	·060	·035	·040	·070	·055	·130	·018	·020	·030	·030		·060
		10	*1,0*	*1,5*	*0,9*	*1,0*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*		*1,5*
7/·064	·0225		·040	·060	·035	·040	·070	·055	·130	·018	·020	·030	·030		·060
		16	*1,0*	*1,5*	*0,9*	*1,1*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*		*1,5*
19/·044	·03		·045	·060	·040	·045	·070	·055	·130	·018	·020	·030	·030		·060
		25	*1,2*	*1,6*	*1,0*	*1,3*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*		*1,5*
19/·052	·04		·050	·065	·045	·050	·070	·055	·130	·018	·025	·030	·030		·060
		35	*1,4*	*1,6*		*1,3*	*1,8*	*1,4*	*3,3*	*0,45*	*0,6*	*0,8*	*1,2*		*1,5*
19/·064	·06		·055	·065		·050	·070	·055	·130	·018	·025	·030	·045		·060
		50		*1,7*		*1,4*	*1,8*	*1,4*	*3,3*			*0,8*	*1,2*		*1,5*
		60		*1,7*		*1,4*	*1,8*	*1,4*	*3,3*			*0,8*	*1,2*		*1,5*
19/·083	·1			·070		·055	·070	·055	·130			·030	·045		·060
		70		*1,8*		*1,4*	*1,8*	*1,4*	*3,3*			*0,8*	*1,2*		*1,5*
		95		*2,0*		*1,5*	*1,8*	*1,4*	*3,3*			*0,8*	*1,2*		*1,5*
37/·072	·15			·080		·060	·070	·055	·130			·030	·045		·060
		120		*2,3*		*1,6*	*1,8*	*1,4*	*3,3*			*0,8*	*1,9*		*1,5*
37/·083	·2			·090		·065	·070	·055	·130			·030	·075		·060
		150		*2,4*		*1,6*	*1,8*	*1,4*	*3,3*			*0,8*	*1,9*		*1,5*
37/·093	·25			·095		·070	·070	·055	·130			·030	·075		·060
		185		*2,5*		*1,9*	*1,8*	*1,4*	*3,3*			*0,8*	*1,9*		*1,5*
37/·103	·3			·100		·075	·070	·055	·130			·030	·075		·060
		240		*2,7*		*2,0*	*1,9*	*1,5*	*3,3*			*0,8*	*1,9*		*1,5*
61/·093	·4			·110		·085	·080	·065	·130			·030	·075		·060
		300		*3,0*		*2,4*	*2,0*	*1,6*	*3,3*			*0,8*	*1,9*		*1,5*
61/·103	·5			·120		·095	·080	·065	·130			·030	·075		·060
		400		*3,2*		*2,5*	*2,0*	*2,0*	*3,3*			*0,8*	*1,9*		*1,5*
91/·103	·75			·130		·105	·090	·080	·130			·030	·075		·060
		500		*3,3*		*2,7*	*2,3*	*2,0*	*3,3*			*0,8*	*1,9*		*1,5*
		625		*3,5*		*2,8*	*2,5*	*2,3*	*3,3*			*0,8*	*1,9*		*1,5*
127/·103	1·0			·140		·110	·100	·090	·130			·030	·075		·060

c/c = between conductors c/s = between conductor and sheath.

NOTE.—Rubber, Rubberlike and P.V.C. thicknesses are the average of a number of measurements.
Tolerance on declared values:— Rubber and Rubberlike 5%+·005 in. (0,13 mm.) P.V.C. up to ·050 in. (1,3 mm.) 5%+·003 in. (0,076 mm.).

TABLE 8.3

THICKNESS OF SHEATH

Diameter under Sheath		Thickness of Sheath (Average)		
Above	Up to and including	Rubber or P.C.P.	P.V.C.	Lead Alloy
in. *mm.*	in. *mm.* 0·25 *6,0*	in. *mm.* ·040 *1,0*	in. *mm.* ·035 *0,9*	in. *mm.* ·040 *1,0*
·25 *6,0*	·5 *12,0*	·050 *1,3*	·045 *1,15*	·045 *1,15*
·5 *12,0*	·75 *19,0*	·060 *1,5*	·055 *1,4*	·055 *1,4*
·75 *19,0*	1·0 *25,0*	·070 *1,8*	·070 *1,8*	·065 *1,65*
1·0 *25,0*	1·25 *31,0*	·080 *2,0*	·080 *2,0*	·075 *1,9*
1·25 *31,0*	1·5 *38,0*	·090 *2,3*	·090 *2,3*	·085 *2,15*
1·5 *38,0*	1·75 *44,0*	·100 *2,5*	·100 *2,5*	·095 *2,4*
1·75 *44,0*	2·0 *51,0*	·110 *2,8*	·110 *2,8*	·105 *2,65*
2·0 *51,0*	2·25 *57,0*	·120 *3,0*	·120 *3,0*	·115 *2,9*
2·25 *57,0*	2·5 *63,0*	·130 *3,3*	·130 *3,3*	·125 *3,15*
2·5 *63,0*	2·75 *70,0*	·140 *3,5*	·140 *3,5*	·135 *3,4*
2·75 *70,0*	3·0 *76,0*	·150 *3,8*	·150 *3,8*	·145 *3,7*
3·0 *76,0*	3·25 *82,0*	·160 *4,0*	·160 *4,0*	·155 *3,9*

Tolerances on declared values:—

P.C.P.	5%+·010 in. (0,25 mm.)
P.V.C. Up to and including ·075 in. (1,9 mm.)	5%+·007 in. (0,18 mm.)
Above ·075 in. (1,9 mm.)	5%+·010 in. (0,25 mm.)
Lead Alloy	5%+·005 in. (0,13 mm.)

For lead-alloy sheath, if the minimum at a point method of measurement is preferred the thickness of sheath is to be at least the values given above reduced by ·010 in. (0,25 mm.)

Choice of Protective Covering

811 Cables fitted in the following locations:—

Decks exposed to the weather
Bathrooms
Cargo holds
Refrigerated spaces
Machinery spaces

or in any other location where water condensation or harmful vapour (e.g., oil vapour) may be present are to have an impervious sheath. In permanently wet situations metallic sheaths are to be used for cables with hygroscopic insulation.

812 All cables are to be of flame-retardant or fire-resisting types (*see* 850) except that flame-extending cables may be used for final circuits only in the following cases:—

(*a*) Where cables are installed in metallic conduits having an internal diameter not exceeding 1 in. (25 mm.) and provided the conduits are mechanically and electrically continuous.

(*b*) Bare lead sheathed cable having conductor sections not exceeding 0·007 sq. in. (4,5 sq. mm.).

Current Rating

813 The highest continuous load carried by a cable is not to exceed its current rating. The diversity factor of the indvidual loads and the duration of the maximum demand may be allowed for in estimating the maximum continuous load and is to be shown on plans submitted for approval.

The voltage drop from the main switchboard busbars to any point in the installation when the cables are carrying maximum current under normal conditions of service, is not to exceed 6 per cent of the nominal voltage.

In assessing the current rating of lighting circuits every lampholder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 watts, unless the fitting is so constructed as to take only a lamp rated at less than 60 watts.

Cables supplying cargo winches, cranes, windlasses and capstans are to be suitably rated for their duty. Unless the duty is such as to require a longer time rating cables for winch or crane motors may be half hour rated on the basis of the half hour b.h.p. of the motors. Cables for windlass and capstan motors are to be not less than one hour rated on the basis of the one hour b.h.p. of the motor. In all cases the rating is to be subject to the voltage drop being within the specified limits.

The following Table 8.4 gives the maximum permissible continuous-current rating for single- and multi-core cables, except that where a more precise evaluation of current rating has been carried out based on experimental or calculated data details may be submitted for approval.

CURRENT RATING IN AMPERES

(Based on ambient temperature 45° C.)

TABLE 8.4 (a)—GENERAL PURPOSE RUBBER AND P.V.C.

Nominal cross section			Single core	2 core	3 or 4 core
	sq. in.	sq. mm.			
1/·044	·0015		9	7	6
		1	9	7	6
3/·029	·002		11	9	7
		1,5	12	10	8
3/·036; 1/·064	·003		14	11	9
		2,5	17	14	11
7/·029	·0045		18	16	13
		4	23	19	16
7/·036	·007		25	21	17
		6	30	25	21
7/·044	·01		31	26	22
7/·052	·0145		37	31	26
		10	41	34	28
7/·064	·0225		51	43	35
		16	54	45	37
19/·044	·03		60	51	42
		25	70	59	49
19/·052	·04		72	61	50
		35	86	73	60
19/·064	·06		92	78	64
		50	105	91	75
		60	120	100	84
19/·083	·1		125	105	87
		70	130	110	91
		95	160	135	110
37/·072	·15		160	135	110
		120	180	155	130
37/·083	·2		190	160	135
		150	210	180	145
37/·093	·25		220	185	155
		185	240	205	170
37/·103	·3		250	210	175
		240	280	240	200
61/·093	·4		300	255	210
		300	325	275	225
61/·103	·5		D.C. 340 A.C.	D.C. 290 A.C.	D.C. 240 A.C.
	·6		380 375	325 320	265 265
		400	390 385	330 325	275 270
91/·103	·75		445 420	375 360	310 295
		500	450 430	380 365	315 300
		625	520 470	440 375	360 330
127/·103	1·0		530 480	450 405	370 335

TABLE 8.4 (b)—HEAT RESISTING RUBBER

Nominal cross section			Single core		2 core		3 or 4 core	
	sq. in.	sq. mm.						
1/·044	·0015		14		11		9	
		1	14		11		9	
3/·029	·002		17		14		11	
		1,5	19		16		13	
3/·036; 1/·064	·003		21		17		14	
		2,5	25		21		17	
7/·029	·0045		27		23		18	
		4	32		27		22	
7/·036	·007		35		29		24	
		6	42		35		29	
7/·044	·01		44		37		30	
7/·052	·0145		55		46		38	
		10	58		49		40	
7/·064	·0225		74		62		51	
		16	78		66		54	
19/·044	·03		87		74		61	
		25	100		86		71	
19/·052	·04		105		89		73	
		35	125		105		88	
19/·064	·06		135		115		94	
		50	155		135		110	
		60	175		150		125	
19/·083	·1		185		155		130	
		70	195		165		135	
		95	235		200		160	
37/·072	·15		235		200		165	
		120	270		230		190	
37/·083	·2		285		240		200	
		150	310		265		215	
37/·093	·25		325		275		225	
		185	355		300		250	
37/·103	·3		365		310		255	
		240	415		355		290	
61/·093	·4		435		370		305	
		300	480		410		335	
61/·103	·5		D.C. 500	A.C.	D.C. 425	A.C.	D.C. 350	A.C.
	·6		560	550	475	465	390	385
		400	570	560	485	475	400	390
91/·103	·75		640	610	540	520	450	425
		500	650	620	550	530	455	435
		625	740	670	630	570	520	470
127/·103	1·0		760	690	650	580	530	480

TABLE 8.4 (c)—VARNISHED CAMBRIC, BUTYL

Nominal cross section			Single core		2 core		3 or 4 core	
	sq. in.	sq. mm.						
1/·044	·0015		15		12		10	
		1	15		12		10	
3/·029	·002		19		16		13	
		1,5	21		17		14	
3/·036; 1/·064	·003		23		19		16	
		2,5	27		22		18	
7/·029	·0045		29		24		20	
		4	35		29		24	
7/·036	·007		38		32		26	
		6	45		38		31	
7/·044	·01		48		40		33	
7/·052	·0145		60		51		42	
		10	63		53		44	
7/·064	·0225		78		66		54	
		16	83		70		58	
19/·044	·03		93		79		65	
		25	110		93		77	
19/·052	·04		115		96		79	
		35	135		115		94	
19/·064	·06		145		120		100	
		50	170		145		115	
		60	185		160		130	
19/·083	·1		195		165		135	
		70	205		175		145	
		95	250		215		175	
37/·072	·15		255		215		180	
		120	290		245		205	
37/·083	·2		300		255		210	
		150	335		285		235	
37/·093	·25		345		295		240	
		185	380		320		265	
37/·103	·3		390		330		270	
		240	445		380		310	
61/·093	·4		465		395		325	
		300	510		435		355	
61/·103	·5		D.C. 530	A.C.	D.C. 450	A.C.	D.C. 370	A.C.
	·6		600	585	510	495	420	410
		400	610	590	520	500	425	415
91/·103	·75		680	640	580	540	475	450
		500	690	640	590	550	485	450
		625	790	680	680	580	550	480
127/·103	1·0		810	690	690	590	570	485

TABLE 8.4 (d) ASBESTOS-VARNISHED CAMBRIC

Nominal cross section			Single core	2 core	3 or 4 core
	sq. in.	sq. mm.			
1/·044	·0015		16	13	11
		1	16	13	11
3/·029	·002		20	17	14
		1,5	22	18	15
3/·036; 1/·064	·003		25	21	17
		2,5	28	23	19
7/·029	·0045		31	26	22
		4	37	31	25
7/·036	·007		41	34	28
		6	48	40	33
7/·044	·01		51	43	35
7/·052	·0145		64	54	44
		10	67	57	47
7/·064	·0225		83	70	58
		16	89	75	62
19/·044	·03		99	84	69
		25	115	99	82
19/·052	·04		120	105	94
		35	145	120	100
19/·064	·06		155	130	110
		50	180	155	125
		60	200	170	140
19/·083	·1		210	180	145
		70	220	185	155
		95	270	220	190
37/·072	·15		270	230	190
		120	310	265	215
37/·083	·2		320	270	225
		150	355	305	250
37/·093	·25		370	315	260
		185	405	345	285
37/·103	·3		415	355	290
		240	475	405	330
61/·093	·4		495	425	350
		300	540	465	380
61/·103	·5		D.C. 570 A.C.	D.C. 480 A.C.	D.C. 400 A.C.
	·6		640 620	545 530	450 435
		400	650 630	550 540	455 440
91/·103	·75		730 680	620 580	510 475
		500	740 690	630 590	520 480
		625	850 730	720 620	590 510
127/·103	1·0		870 740	740 630	610 520

TABLE 8.4 (e) SILICONE RUBBER, MINERAL

Nominal cross section			Single core	2 core	3 or 4 core
	sq. in.	sq. mm.			
1/·044	·0015		19	16	13
		1	20	17	14
3/·029	·002		23	19	16
		1,5	25	21	17
3/·036; 1/·064	·003		27	23	18
		2,5	31	26	21
7/·029	·0045		34	29	23
		4	41	35	28
7/·036	·007		44	37	30
		6	53	45	37
7/·044	·01		56	47	39
7/·052	·0145		70	59	49
		10	73	62	51
7/·064	·0225		93	79	65
		16	99	84	69
19/·044	·03		110	93	77
		25	130	110	92
19/·052	·04		135	115	94
		35	165	140	115
19/·064	·06		175	150	125
		50	205	175	145
		60	230	195	160
19/·083	·1		240	205	170
		70	255	215	175
		95	310	265	215
37/·072	·15		315	265	220
		120	360	305	250
37/·083	·2		380	325	265
		150	420	355	290
37/·093	·25		440	375	310
		185	485	410	340
37/·103	·3		500	425	350
		240	570	485	400
61/·093	·4		600	510	420
		300	660	560	460
61/·103	·5		690	590	485

Correction Factors for Current Rating

814 (*a*) BUNCHING OF CABLES—Where more than six cables belonging to the same circuit are bunched together a correction factor of 0·85 is to be applied.

(*b*) AMBIENT TEMPERATURE—When it is known that the ambient temperature is different from that given in M 106 the following correction factors are to be applied.

TABLE 8.5

Insulation	Correction Factor for Ambient Temperature			
	40°C. (104°F.)	45°C. (113°F.)	50°C. (122°F.)	55°C. (131°F.)
Rubber or P.V.C. (general purpose)	1·15	1·00	0·82	—
Rubber (heat-resisting quality)	1·08	1·00	0·91	0·82
Varnished Cambric, Butyl	1·07	1·00	0·93	0·85
Asbestos-Varnished Cambric	1·06	1·00	0·94	0·87
Mineral, Silicone Rubber...	1·05	1·00	0·95	0·89

(*c*) INTERMITTENT SERVICE—Where the load is intermittent the correction factors in Table 8.6 may be applied for half hour and one hour ratings. In no case is a shorter rating than one half hour rating to be used, whatever the degree of intermittency.

Installation of Cables

815 Cable runs are to be, as far as possible, straight and accessible.

816 The installation of cables across expansion joints in the ship's structure is to be avoided. Where this is not practicable a loop of cable of length proportional to the expansion of the joint is to be provided. The internal radius of the loop is to be at least 12 times the external diameter of the cable.

817 Where a duplicate supply is required the two cables are to follow different routes which are to be as far apart as practicable.

818 Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, where this is not practicable, the cables are to be operated so that no cable

TABLE 8.6

Correction Factor	Half Hour Rating		One Hour Rating	
	With Metallic Sheath	Without Metallic Sheath	With Metallic Sheath	Without Metallic Sheath
1·0	Up to ·03 sq. in. 20 sq. mm.	Up to ·1 sq. in. 75 sq. mm.	Up to ·1 sq. in. 67 sq. mm.	Up to ·3 sq. in. 230 sq. mm.
1·1	·04–·06 sq. in. 21–40 sq. mm.	·15 sq. in. 76–125 sq. mm.	·15–·25 sq. in. 68–170 sq. mm.	·4–·6 sq. in. 231–400 sq. mm.
1·15	·1 sq. in. 41–65 sq. mm.	·2–·25 sq. in. 126–180 sq. mm.	·3–·4 sq. in. 171–290 sq. mm.	·75–1·0 sq. in. 401–600 sq. mm.
1·2	66–95 sq. mm.	·3 sq. in. 181–250 sq. mm.	·5–·6 sq. in. 291–430 sq. mm.	
1·25	·15–·2 sq. in. 96–130 sq. mm.	·4 sq. in. 251–320 sq. mm.	·75–1·0 sq. in. 431–600 sq. mm.	
1·3	·25 sq. in. 131–170 sq. mm.	·5–·6 sq. in. 321–400 sq. mm.		
1·35	·3 sq. in. 171–220 sq. mm.	·75 sq. in. 401–500 sq. mm.		
1·4	·4 sq. in. 221–270 sq. mm.			

reaches a temperature higher than that permitted for the lowest temperature-rated cable in the group.

819 Cables having a protective covering which may damage the covering of other cables are not to be bunched with those other cables.

820 When installing cables the minimum internal radius of bend is to be generally in accordance with :—

6 d for rubber and PVC cables with metal covering

6 d for rubber and PVC cables exceeding 1 in. (25,4 mm.) diameter and without metal covering

4 d for rubber and PVC cables exceeding ·375 in. (9,5 mm.) diameter and without metal covering

8 d for varnished cambric cables

4 d for mineral-insulated cables

(d=overall diameter of cable)

Mechanical Protection

821 Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit unless the protective covering (e.g., armour or sheath) is sufficient to withstand the possible damage.

822 Cables in cargo holds and other spaces where there is exceptional risk of mechanical damage are to be suitably protected, even if armoured, unless the steel structure affords adequate protection. (*See also* M 1613.)

823 Metal casings for mechanical protection of cables are to be efficiently protected against corrosion.

Earthing

824 Metal coverings of cables are to be effectively earthed at both ends of the cable, except in final sub-circuits where earthing at the supply end only will be considered adequate. This does not necessarily apply to instrumentation cables where single point earthing may be desirable for technical reasons.

825 The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and tappings is to be ensured.

826 The lead sheath of lead-sheathed cables is not to be used as the sole means of earthing the non-current carrying parts of items of equipment.

Securing of Cables

827 Cables are to be effectively supported and secured without their coverings being damaged.

828 The distances between supports is to be chosen according to the type of cable, the distances being generally in accordance with Table 8.7 below.

829 Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection.

Penetration of Bulkheads and Decks

830 Penetration of watertight bulkheads or decks is to be carried out with either individual watertight glands or with packed watertight boxes carrying several cables. However carried out the watertight integrity of the bulkheads or deck is to be maintained. (*See also* 810.)

831 Cables passing through decks are to be protected by deck tubes or ducts.

832 Where cables pass through non-watertight bulkheads or structural steel the holes are to be bushed with lead or other approved material. If the steel is ·25 in. (6 mm.) thick, adequately rounded edges may be accepted as the equivalent of bushing.

833 Materials used for glands and bushings are to be such that there is no risk of corrosion.

834 Where rectangular holes are cut in bulkheads or structural steel the corners are to be radiused.

TABLE 8.7

External diameter of Cable		Non-Armoured Cables	Armoured Cables
Exceeding	Not Exceeding		
—	0·3 in. (7,6 mm.)	8 in. (20 cm.)	10 in. (25 cm.)
0·3 in. (7,6 mm.)	0·5 in. (12,7 mm.)	10 in. (25 cm.)	12 in. (30 cm.)
0·5 in. (12,7 mm.)	0·75 in. (20 mm.)	12 in. (30 cm.)	14 in. (35 cm.)
0·75 in. (20 mm.)	1·25 in. (30 mm.)	14 in. (35 cm.)	16 in. (40 cm.)
1·25 in. (30 mm.)	—	16 in. (40 cm.)	18 in. (45 cm.)

Installation in Pipes and Conduits

If installed in pipe or conduit the following rules are to be complied with.

835 Metal conduit systems are to be earthed and are to be mechanically and electrically continuous across joints. Individual short lengths of conduit need not be earthed.

836 The internal radius of bend of pipes and conduit is to be not less than that laid down for cables provided that for pipes exceeding 2·5 in. (64 mm.) diameter the internal radius of bend is not less than twice the diameter of the pipe.

837 The drawing-in factor (ratio of the sum of the cross sectional areas of the cables to the internal cross section area of the pipe) is not to exceed 0·4.

838 Expansion joints are to be provided where necessary.

839 Where necessary, ventilation openings are to be provided at the highest and lowest points so as to permit air circulation and to prevent accumulation of water.

Where cables are laid in trunks the trunks are to be so constructed as not to afford passage for fire from one between deck or compartment to another.

840 High voltage cables, e.g., those used for cold cathode luminous discharge lamps, are not to be installed in metal conduit unless protected by metal sheath or screen.

841 Non-metallic ducting or conduit is to be of flame-retardant material. PVC conduit is not to be used in refrigerated spaces or on open decks, unless specially approved.

Installation in Refrigerated Spaces

842 Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be protected against mechanical damage. If an armoured cable is used the armour, unless galvanized, is to be protected against corrosion by a further moisture-resisting covering.

Cables entering a refrigerated space are to pass directly through the walls or lagging and are to be protected by a tube sealed at each end. Alternatively, the cables may be passed through solid door frames the necessary holes being sealed at each end.

Precautions are to be taken to prevent the placing of hooks round the cable as a casual means of suspension.

Where PVC insulated cables are used in refrigerated spaces a low temperature grade is to be used.

Cables for Alternating Current

843 Where it is necessary to use single-core cables for alternating-current circuits rated in excess of 20 A the following rules are to be complied with :—

(*a*) Cables are to be either non-armoured or armoured with non-magnetic material.

(*b*) If installed in pipe or conduit, cables belonging to the same circuit are to be installed in the same conduit, unless the conduit or pipe is of non-magnetic material.

(*c*) Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

(*d*) When installing two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits or three-phase and neutral circuits the cables are to be in contact with one another, as far as possible. In any event the distance between adjacent cables is not to be greater than 1 diameter.

(*e*) If single-core cables, of current rating greater than 250 A are run along a steel bulkhead wherever practicable the cables should be spaced away from the steel.

(*f*) Where single core cables of rating exceeding 50 A are used, magnetic material is not to be placed between single-core cables of a group. If these cables pass through steel plates, all cables of the same circuit are to pass through a plate or gland so constructed that there is no magnetic material between the cables and suitable clearance is provided between the cable core and magnetic material. This clearance, wherever practicable, is to be not less than 3 in. (75 mm.) when the current exceeds 300 A. For currents between 50 A and 300 A the clearance is to be obtained by interpolation.

Cable Ends

844 The ends of all conductors of cross-sectional area greater than 0·0065 sq. in. (4 sq. mm.) are to be fitted with soldering sockets, compression type sockets or mechanical clamps. Corrosive fluxes are not to be used.

Cables having a hygroscopic insulation (e.g., varnished cambric or mineral insulated) are to have their ends sealed against ingress of moisture.

Cables with a supplementary insulating belt beneath the protective sheath are to have additional insulation at those points where the insulation of each core makes or may make contact with earthed metal.

Joints and Branch Circuits

845 If a joint is necessary it is to be carried out so that all conductors are adequately secured, insulated and protected from atmospheric action. Terminals or busbars are to be of dimensions adequate for the cable rating.

Testing

846 The following tests are to be made at the manufacturers' works prior to despatch and may be required to be carried out under the supervision of the Surveyors.

All main cable for electric propelling machinery is to be tested in the presence of the Surveyors. (*See* M 1701.)

High Voltage Test

847 The test is to be carried out on finished cables with either direct-current or single-phase alternating-current at the manufacturers' discretion. The power available in the test equipment is to be sufficient to maintain in the cable the specified test voltage and the charging current. The voltage is to be applied gradually so as to arrive at the specified figure in approximately one minute. The test voltage is to be applied as follows :—

For cables with metallic covering the test voltage is to be applied between conductor(s) and the metallic covering. For cables with non-metallic impervious sheath the voltage is to be applied between conductor(s) and the water in which the cable is to be immersed for at least one hour before the test. For cables having a non-metallic covering which might be impaired if immersed in water, the voltage is to be applied to samples, at least 40 in. (1 m.) long, the surface being covered with metal foil. In addition, for multi-core cables the voltage is to be applied in turn between each conductor and all other conductors connected together.

The test voltage in all cases is to be applied for 5 minutes, without failure, the value being in accordance with :—

TABLE 8.8

Rated Voltage of Cable		Test Voltage	
Above	Up to and including	A.C. Volts	D.C. Volts
	250	1500	3000
250	750	2500	5000
750	1100	3000	6000
1100	3300	10000	20000
3300	6600	16000	32000

NOTE.—For mineral insulated cables having a rated voltage up to and including 440 V the test voltage is to be 2000 V alternating current and for voltages above 440 V the test voltage is to be 3000 V alternating current.

Insulation Resistance

848 Immediately after the high voltage test the insulation resistance is to be measured and recorded, using a direct-current voltage of at least 400 V and the measurement being made after electrification for 1 minute. (*See also* M 2002.)

Spark Testing

849 Spark testing may be accepted as an alternative to the high voltage and insulation resistance test for cables with rubber or rubber-like insulation. The test is to be made at the core stage except for single core braided and compounded cables which may be tested at the finished stage.

The core or cable is to withstand the test voltage without failure and the speed at which the cable passes through the electrode is to be such that every point is in contact with the electrode for not less than 0·1 sec. Test voltages are given in Table 8.9.

TABLE 8.9

Rated Voltage of Cable V	Conductor Sectional Area		Test Voltage (r.m.s.) kV
	Above	Up to and including	
250	—	·0225 sq. in. (16 sq. mm.)	6
	·0225 sq. in. (16 sq. mm.)	·04 sq. in. (25 sq. mm.)	8
	·04 sq. in. (25 sq. mm.)		10
660	—	·04 sq. in. (25 sq. mm.)	10
	·04 sq. in. (25 sq. mm.)		12

Flame-Extending, Flame-Retardant and Fire-Resisting Cables

850 A sample of cable 48 in. (1,2 m.) long is to be clamped vertically in a three-sided enclosure with open top, of size suitable to contain the cable. A bunsen burner of nominal bore $\frac{3}{8}$ in. (10 mm.) fed with ordinary illuminating gas at normal pressure, giving a flame approximately 5 in. (125 mm.) long with an inner blue cone approximately 1·5 in. (40 mm.) long, is to be applied to the cable so that the tip of the blue cone touches the cable at approximately 12 in. (0,4 m.) from its lower end. The burner is to be held at 45° to the vertical and the flame applied for a time

$$t \text{ (secs)} = 10 + \frac{W}{50}$$

where W = weight of cable sample in grams.
The application is not to be continuous but in steps of 10 seconds, with 10 seconds interruption between applications.

At the end of this period the burner is to be removed and cables are to be graded as follows:—

(*a*) Flame extending when the flame travels along the whole length of the specimen.

(*b*) Flame retardant when the flame extinguishes before reaching the top of the specimen.

(*c*) Fire resisting when, in addition to (b) the specimen is able to withstand after cooling an alternating-current test voltage of twice its rated voltage for 1 minute.

NOTE.—To ensure correct heat in the gas flame a bare copper wire 0·028 in. (0,7 mm.) diameter and of length 4 in. (100 mm.) is to be inserted horizontally in the flame and 2 in. (50 mm.) above the top of the burner, so that the free end of the wire is vertically above the edge of the burner on the side of the burner remote from the supported end of the wire. If the wire takes more than 6 seconds to melt then the flame is not hot enough for the test.

Other tests which are the equivalent of the above may be submitted for consideration.

Quality of Materials

851 The quality of materials is to be in accordance with the recommendations of I.E.C. Publication 92.

Alternative requirements of National Standards will be considered.

Section 9

TRANSFORMERS

901 The following Rules apply to all transformers for general use rated from 1 kVA to 1000 kVA inclusive and suitable for operating over an input voltage range up to 3300 volts line to line.

Transformers outside these limits will be specially considered.

Construction

902 Transformers except those for motor starting are to be double wound.

Liquid Cooled Transformers

903 Proposals for the use of liquid cooled transformers will be specially considered.

Number and Rating of Transformers

904 Where essential services are supplied the number and ratings of transformers are to be sufficient to ensure the operation of essential services even when one transformer is out of service.

Regulation

905 The inherent regulation at 0·8 power factor is not to exceed 5 per cent.

Regulation of the complete system is to comply with M 813.

Temperature Rise

906 The temperature rise of windings of dry type transformers above the ambient temperatures given in M 106, when measured by resisitance, during continuous operation at the maximum rating is not to exceed:—

Class A 50° C.
Class E 60° C.
Class B 70° C.

Proposals to use Class H or Class C insulation will be specially considered.

Short Circuit

907 All transformers are to be capable of withstanding, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any winding for 2 secs.

Tests

908 The following tests are to be carried out on all transformers at the manufacturers' works, and a certificate of tests issued by the manufacturer.

HIGH VOLTAGE TEST

(*a*) The voltage is to be applied to each winding in turn between the winding under test and the remaining windings, core, frame and tank or casing connected together and to earth.

The test is to be made with 1 kV a.c. plus twice the highest voltage between lines with a minimum of

2·5 kV at any frequency between 25 c/s and 100 c/s and maintained for 1 minute without failure.

INDUCED HIGH VOLTAGE TEST

(*b*) To test between turns, coils and terminals an a.c. voltage is to be applied between the above parts corresponding to twice the voltage appearing between these parts when rated voltage is applied to the terminals. The duration of the test is to be 1 minute for any test frequency up to and including twice the rated frequency.

INSULATION RESISTANCE

(*c*) The insulation resistance of each winding in turn to all the other windings, core, frame and tank or casing connected together and to earth is to be measured and recorded together with the temperature of the transformer at the time of the test.

TEMPERATURE RISE

(*d*) One transformer of each size and type is to be given a temperature rise test.

Section 10

LIGHTING

1001 Lighting which is essential for the safety and the working of the ship is to comply with the following Rules :—

The voltage of tungsten filament lampholders is not to exceed :—

BAYONET FITTING		
Normal	B 22	250 V
Small (single contact)	B 15s	130 V
Small (double contact)	B 15d	130 V
SCREW FITTING		
Goliath	E 40	250 V
Medium	E 27	250 V
Small	E 14	250 V
Miniature	E 10	24 V

Lamps are to be in accordance with the following :—

B 22 up to 200 W
E 27 up to 200 W
E 40 no limit

Lampholders are to be constructed of flame-retarding and non-hygroscopic material. All metal parts are to be of robust construction. Goliath lampholders are to be provided with means for locking the lamp in the holder. The temperature of cable connections is not to exceed the maximum conductor temperature permitted for the cable given in M 802.

Fluorescent Lighting

1002 Fittings, reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are subject to high temperatures. In ships for unrestricted service they are to be capable of operating at the ambient temperatures given in M 106.

Capacitors of 0·5 microfarads and above are to be provided with a means of prompt discharge on disconnection of the supply.

Inductors and high reactance transformers are to be installed as close as practicable to the associated discharge lamp.

1003 Where cold cathode luminous discharge lamps of normal operating voltage above 250 V are used a warning notice calling attention to the voltage is to be displayed at points of access to the lamps and where otherwise necessary.

1004 Emergency lighting is to be fitted in accordance with M 111.

Section 11

ACCESSORIES

Enclosures

1101 Enclosures are to be of metal or of flame-retardant insulating materials.

Inspection and Draw Boxes

1102 If metal conduit systems are used inspection and draw boxes are to be of metal and are to be in rigid electrical and mechanical connection with the conduits.

Socket Outlets and Plugs

1103 Where it is necessary to earth the non-current-carrying parts of portable or transportable equipment an effective means of earthing is to be provided at the socket outlet.

On weather decks, galleys, laundries, machinery spaces and all wet situations, socket outlets and plugs are to be effectively shielded against rain or spray and are to be provided with means of maintaining this quality after removal of the plug.

The temperature rise on the live parts of socket outlets and plugs is not to exceed 30° C. Socket outlets and plugs are to be so constructed that they cannot be readily short circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket outlet.

All socket outlets of current rating 15 A or more are to be provided with a switch.

Section 12

HEATING AND COOKING EQUIPMENT

1201 Heaters are to be so constructed, installed and protected that clothing, bedding and other inflammable material cannot come in contact with them in such a manner as to cause risk of fire. There is to be no excessive heating of adjacent bulkheads or decks.

Section 13

BATTERIES

The following Rules apply to permanently installed secondary batteries.

Construction

1301 The cells of all batteries are to be so constructed and secured as to prevent spilling of the electrolyte due to the motion of the ship and to prevent emission of acid or alkaline spray.

Location

1302 Alkaline batteries and lead acid batteries are not to be installed in the same compartment.

Large batteries are to be installed in a space assigned to the batteries only or alternatively in a deck box if such a space is not available.

Engine starter batteries are to be located as close as practicable to the engine(s) served. If such batteries cannot be accommodated in the battery room they are to be installed so that adequate ventilation is ensured.

Lining of Compartments

1303 Where acid is used as the electrolyte a tray of lead, or wood lined with lead is to be provided below the cells. Alternatively, the deck below the cells is to be protected with lead or other acid-resisting material so as effectually to prevent any acid from lodging in contact with the ship's structure.

The interiors of all battery compartments including shelves are to be painted with corrosion-resistant paint.

Equipment

1304 Switches, fuses and other electrical equipment liable to cause an arc are not to be fitted in battery compartments.

Supports

1305 Batteries are to be so arranged that each cell or crate of cells is accessible from the top and at least one side. Cells or crates are to be carried on non-absorbent insulating supports. Similar insulators are to be fitted to prevent any movement of cells arising from the motion of the ship.

Ventilation

1306 Battery compartments are to be ventilated by an independent ventilating system.

Natural ventilation may be employed if ducts can be run directly from the top of the compartment to the open air with no part of the duct more than 45° from the vertical. If natural ventilation is impracticable mechanical ventilation is to be provided. Interior surfaces of ducts and fans are to be painted with corrosion-resistant paint. Fan motors are not to be located in the air stream.

All openings through the battery compartment bulkheads or decks, other than ventilation openings are to be effectively sealed to reduce the possibility of escape of gas from the battery compartment, into the ship.

Where practicable, battery lockers are to be ventilated similarly to battery compartments.

Deck boxes are to be adequately ventilated and means provided to prevent ingress of water.

Size of Batteries and Charging Facilities

1307 Where batteries are used for starting main engines at least two batteries are to be fitted of such combined size that H 711 is complied with.

Adequate charging facilities are to be provided and where batteries are charged from line voltage, by means of a series resistor, protection against reversal of current is to be provided when the charging voltage is 20 per cent of line voltage or higher.

In d.c. systems means are to be provided to isolate the batteries from the low voltage system when being charged from a higher voltage system.

Protection

1308 Batteries, except starter batteries, are to be protected against short circuit by a fuse in each insulated conductor or a multi-pole circuit-breaker at a position adjacent to the battery compartment.

1309 A permanent notice is to be fitted to all battery compartments prohibiting naked lights and smoking.

Section 14

INTERNAL COMMUNICATIONS

1401 Where a communication circuit takes its supply direct from power or lighting circuits and in other cases where the voltage of supply exceeds 50 V a.c. or 60 V d.c. all equipment is to be in accordance with the Rules for power and lighting circuits.

1402 Cables are to be fitted in a similar manner to cables installed for lighting and power, but are to be segregated from the latter unless either the lighting and power cables or the communication cables are metal sheathed, or non-metallic impervious sheathed.

1403 Communication circuits other than those supplied from primary batteries are to be protected against overload and short circuit.

Passenger Alarms

1404 In all passenger ships, except those engaged on short international voyages, electrically operated alarms, for summoning passengers to muster stations are to be fitted. They are to be operable from the bridge.

Steering Gear

1405 Means of communication are to be fitted to enable orders to be transmitted from the bridge to the alternative steering station required by D 2706.

Section 15

SEMI-CONDUCTOR RECTIFIERS FOR POWER

1501 Rectifier stacks are to be so arranged that they may be removed from equipment without dismantling the complete unit.

1502 Where forced cooling is provided the apparatus is to be so arranged that the rectifier cannot remain loaded unless effective cooling is maintained.

1503 When necessary, means are to be provided to guard against d.c. voltage rise due to regenerated power.

1504 When operated in parallel with other sources of d.c. power load sharing is to be such that under normal conditions overloading of any unit does not occur and the combination of paralleled equipment is stable.

1505 Fungus protection of the mercury type is not to be used in the vicinity of selenium rectifiers.

1506 Monocrystalline rectifiers such as germanium and silicon are to be capable of withstanding the effects of transient over-voltages coming from the ship's network.

Section 16

SPECIAL REQUIREMENTS FOR OIL TANKERS AND SHIPS INTENDED FOR THE CARRIAGE IN BULK OF LIQUID CARGOES HAVING A FLASH POINT OF 150° F. (65,5° C.) OR LESS

Generation and Distribution

1601 The following generation and distribution systems only are to be used :—

Two-wire insulated for d.c. and single-phase a.c.

Three-wire insulated for three-phase a.c.

1602 No current-carrying part of the distribution system is to be earthed other than through an earth indicating device or capacitors used for radio interference suppression.

Equipment in Dangerous Spaces

1603 No electrical equipment or wiring, other than that certified intrinsically safe in respect of the gases and vapours involved (*see* M 109) is to be installed in any space where inflammable or explosive vapour may normally be expected to accumulate such as :—

Cargo oil tanks.

Cofferdams adjoining cargo oil tanks.

Cargo pump rooms.

Enclosed spaces immediately above cargo tank crowns (e.g., between decks).

Enclosed spaces, other than cofferdams, adjacent to, and below, the top of a cargo oil tank.

On open deck within 10 ft. (3 m.) of any oil tank outlet or vapour outlet.

except as detailed in 1604 to 1609.

1604 In enclosed spaces immediately above cargo tank crowns lighting fittings only are to be installed and they are to be of flameproof type. The switches controlling such fittings are to be double-pole and are to be located in a safe place. Through runs of cable are permitted.

1605 Electrical equipment additional to the lighting fittings referred to in 1604 above may be installed in between deck spaces immediately above cargo tank crowns provided that :—

(*a*) Such equipment is housed in a suitably ventilated compartment having access solely from the deck above, and of which the floor is separated from the cargo oil tanks by a cofferdam, and the boundaries are gas tight with respect to the cofferdam and the between deck space.

(*b*) Cables are supported clear of the gas tight boundaries of the compartment. Plans showing the construction of the compartment, the electrical apparatus to be housed therein and the provisions for ventilation are to be submitted.

1606 In positions on open deck and within a distance of 10 ft. (3 m.) from cargo tank hatches, sight ports, tank cleaning openings, ullage openings, sounding pipes, cargo vapour outlets or ventilators, or cargo pump room entrances electrical equipment is to be flameproof.

1607 Hull fittings containing the oscillators of electric sounding devices may be installed in a cofferdam or cargo pump room forward of the oil tanks provided that :—

(*a*) Such fittings are housed in a gas tight enclosure clear of the cargo tank bulkhead.

(*b*) The cables to the oscillators are run within the space in heavy gauge galvanized steel pipe with bolted flange joints and led through watertight glands fitted at the external extremity of the pipe.

1608 Cargo pump rooms may be lit by one or both of the following methods :—

(*a*) By flameproof fittings within the compartment. The lamps are to be arranged on at least two independent circuits controlled by fuses and double-pole switches located in a safe space outside the compartment. The lamps and corresponding switches and fuses are to be suitably labelled for identification purposes. Well glasses and other covers are to be secured by screws or nuts requiring a special key for their removal. The cables are to comply with 1613, protected from mechanical damage and supported clear of bulkheads and deckheads.

(*b*) By fittings located in a safe space. Where a safe space is immediately adjacent the cargo pump rooms may be lighted either :—

(i) From that safe space through gas tight and watertight glazed ports permanently fitted in the bulkhead or deckhead.

(ii) Or by lighting fittings which are flameproof relative to the cargo pump room and gas tight relative to the safe space and so designed to admit replacement of the lamp from the safe space.

1609 Enclosed spaces other than cofferdams adjacent to and below the top of a cargo tank may be lighted in the same manner as cargo pump rooms. The provisions for ventilation are to be submitted for approval. (*See* D 4012.)

Portable Lamps

1610 Portable lamps other than self-contained battery fed or equivalent lamps of a certified type, in respect of the gases and vapours involved, are not to be used in any dangerous space.

Lighting Fittings

1611 Except in accommodation spaces enclosing cases of lighting fittings are to be of metal or equally durable and non-inflammable approved material.

Fuses

1612 Only cartridge-type fuses are to be used.

Cables on Fore and Aft Gangways and in Dangerous Spaces

1613 Cables on fore and aft gangways and in dangerous spaces, where permitted, are to be sheathed with one of the following :—

(i) Copper sheath (for mineral insulated cable).

(ii) Lead sheath plus further mechanical protection, e.g. armour or non-metallic impervious sheath.

(iii) Non-metallic impervious sheath plus armour.

Where corrosion may be expected non-metallic impervious sheath, or equivalent protection, is to be applied over steel armour for corrosion protection.

1614 Cables installed on deck in way of cargo tanks or on fore and aft gangways are to be protected against mechanical damage. Where pipes are used the total cross-sectional area of the cables contained

within a pipe is not to be more than 30 per cent of the internal cross-sectional area of the pipe. Glands are to be fitted at each bulkhead through which the pipes pass, to allow for expansion and the working of the ship. The pipe system is to be drained and ventilated.

1615 All cables except mineral-insulated copper sheathed cables installed on deck in way of cargo tanks, or on fore and aft gangways and all pipes containing such cables are to be kept throughout their length at such distance from steam and exhaust pipes as to be substantially free from any heating effect from such pipes. At the bulkhead this distance is to be not less than 18 in. (450 mm.) from the flanges of steam pipes more than 3 in. (75 mm.) in diameter, and not less than 12 in. (300 mm.) from the flanges of steam pipes 3 in. (75 mm.) or less in diameter.

Flameproof Equipment

1616 Where flameproof equipment is required, effective means of complete isolation located in a safe space is to be provided. Effective provision is to be made to prevent unauthorised operation resulting in restoration of supply while the risk of exposing live conductors exists.

Intrinsically Safe Equipment

1617 Where intrinsically safe equipment is installed the wiring of the circuit is to be physically separated from that of other circuits. Intrinsically safe equipment may be used where flameproof equipment is required by the Rules.

Section 17

ELECTRIC PROPELLING MACHINERY

General

1701 All electric propelling machinery including switchgear, control gear, cables, main and auxiliary generators, motors and exciters is to comply with the relevant sections of the Rules and is to be constructed under special survey.

1702 Prime movers are to comply with the relevant sections of Chapter H.

1703 Armature shafts and other important steel forgings and castings are to comply with the requirements of Chapter P.

1704 The torsional vibration characteristics of the propulsion system are to be submitted as required by H 302 or H 602 whichever is applicable.

1705 Cooling water and lubricating oil systems are to comply with E 8 and E 9 where applicable.

General Arrangements

1706 Where the arrangements permit a propulsion motor to be connected to generating plant having a continuous rating greater than the motor rating, means are to be provided to limit the continuous input to the motor to a value not exceeding the continuous full load torque for which the motor and shafts are approved.

1707 Motors of 500 h.p. or over and generators of 400 kW or over are to be provided with means for heating the windings to prevent condensation when idle. If steam pipes are used for this purpose the joints are not to be within the machine.

Excitation

1708 Systems dependent on the auxiliary generators for excitation are to be capable of manœuvring and of maintaining power at all times with a fall of 10 per cent excitation voltage at the busbars.

Where motor driven exciters, boosters, balancers or rectifiers are provided for excitation purposes, provision for an alternative supply of excitation is to be made. Where two machines are used each of at least 50 per cent of the required power it will be sufficient to provide one spare machine.

1709 Negative boosters are to be provided with overspeed protection, where necessary.

1710 In d.c. constant pressure systems arrangements for generator and motor excitation are to be such that if the motor excitation circuit is opened by a switch or contactor the generator excitation is simultaneously interrupted or the generator voltage is immediately reduced to zero.

1711 VOLTAGES—No voltage limitations are specified.

Manœuvring Controls

1712 When two or more control stations are provided indicating lights are to be located at each control to indicate which station is in control.

1713 Where bridge or deck control is employed alternative control in the engine room is to be provided.

1714 Suitable interlocks, operating preferably by mechanical means are to be provided to prevent damage to the plant as a result of incorrect switching, such as the opening of switches or contactors not intended to be operated while carrying current.

1715 Provision is to be made for the manual operation without undue manual effort, of all manœuvring contactors, switches, field regulators and controllers. Where electric, pneumatic or hydraulic aid is used for normal operation, failure of such aid is not to result in interruption of power to the propeller shaft and any such device is to be capable of purely manual operation without delay. This latter requirement does not apply to bridge control equipment.

Alternative arrangements will be specially considered.

Cables

1716 Conductors in circuits essential for manœuvring or maintenance of propelling power are to be stranded having not less than seven strands and shall have a nominal cross sectional area of not less than 0·0045 sq. in. or 2,5 sq. mm.

1717 Cables which are connected to the slip rings of synchronous motors are to be suitably insulated for the voltage to which they are subjected during manœuvring.

1718 All joints are to be so made as to inhibit corrosion. They are to be arranged and supported in a manner suitable for withstanding the electro-mechanical forces due to short-circuit.

Overload and Short-Circuit Protection

1719 Provision is to be made for protection against severe overloads, and electrical faults likely to result in damage to the plant.

Earth Leakage Detection

1720 The main propulsion circuit is to be provided with means for detecting earth faults. For direct-current equipments exceeding 500 V and for all alternating-current equipments, aural and visual alarms are to be automatically operated on the occurrence of an earth fault, but the operation of such devices is not to interrupt the power supply. A switch may be provided to switch off the aural device, but in such cases the visual alarm shall remain switched on to indicate that the aural device is switched off. Alternative arrangements will be specially considered. If an earth connection is used for operating the detector arrangements then in direct-current systems the earth circuit is to be automatically opened in order to stop the circulation of fault current. In alternating-current systems the fault current is to be interrupted or limited to a safe value.

1721 Earth leakage devices are to be arranged to function for all earth faults exceeding 5 amp. In three-phase star connected alternating-current generators and motors with neutral points earthed, the earth leakage device shall operate on the occurrence of an earth fault in the windings of the machine, subject to the provision that 5 per cent of the coils at the neutral end of each phase may be left unprotected by the device. In high voltage a.c. systems where the capacitive leakage current is high consideration will be given to increasing this figure of 5 per cent.

1722 Excitation circuits are to be provided with lamps, voltmeters or other means to indicate continuously the state of the insulation of the excitation circuits under running conditions.

Discharge Protection

1723 For the protection of field windings and cables, means are to be provided for limiting the inducted voltage when the field circuits are opened, or alternatively the induced voltage, when the field circuits are opened, is to be taken at the nominal design voltage.

1724 Where excitation is obtained from the auxiliary busbars means are to be provided to limit the voltage induced at the busbars when the auxiliary circuit-breaker or the distribution circuit-breaker opens.

1725 Shunt resistors which are connected across the field circuit of synchronous propulsion motors when they are functioning as asynchronous motors are to be suitably insulated for the voltage induced when reversing and are to be amply rated to allow for inadvertent delay during the reversing operation.

Safety Devices

1726 Where separately driven direct-current generators are connected electrically in series means are to be provided to prevent reversal of the direction of rotation of any of them on the failure of the prime mover.

1727 Where, on stopping or reversing the propeller, the regenerated energy transmitted by the propulsion motor is such as to cause a dangerous increase of speed in the prime mover means are to be provided for suitably absorbing or limiting such energy.

1728 Contactors and switches used for reversing the rotation of the propulsion motors are to be provided with means for forcibly opening them if they should inadvertently remain closed and they are to be so interlocked as to prevent the circuits for ahead and astern being closed simultaneously.

Alarms

1729 An aural alarm device is to be provided for machines having enclosed ventilating systems, arranged to operate in the event of the temperature of the heated air exceeding the predetermined safe value.

Identification

1730 All important circuits, instruments and apparatus are to be clearly labelled for identification.

Section 18

SPECIAL REQUIREMENTS FOR HIGH VOLTAGE SYSTEMS (*see* M 203)

NOTE.—High Voltage refers to a marine electrical supply system operating at a voltage in excess of 500 V, 3-phase, a.c.

Introduction

1801 High voltage generation and distribution may be considered appropriate when :—

(*a*) The system fault power under normal operating conditions exceeds 50 MVA.

(*b*) The capacity of individual generating sets is in excess of 2500 kW.

Generation and Distribution

1802 Arrangements are to be made so that it is possible to split the main H.V. switchboard into at least two independent sections, each supplied by at least one generator. The switchboard sections should preferably be located in separate compartments.

1803 The distribution system is to be such that essential services which are duplicated are supplied from separate sections of the switchboard.

Insulated Neutral Systems

1804 For insulated neutral systems special consideration is to be given to the dielectric strength of all high voltage equipment.

1805 In order to preserve the same standard of insulation as with 500 V equipment and to guard against overvoltages which may arise with the insulated neutral system, the test voltage during the high voltage test is to be not less than 7·5 times line to neutral voltage and is to be applied for not less than one minute.

For rotating machinery this extra high voltage test may be replaced by :—

(i) An interturn test on a sample coil

and (ii) The normal high voltage test carried out on the completed machine (*see* M 428).

The interturn test, between adjacent turns which are not connected in parallel, is to be a type test on the particular insulation system used. The test is to be taken between any adjacent effective turns where the greatest voltage is expected in service. The test is to be made on a coil in the fully processed condition, as it would be in the finished winding and the method of making the test and its duration is to be as in M 428 but preferably at the frequency of the ship's system.

The magnitude of the test withstand voltage is to be as given in Table 18.1.

TABLE 18.1

Type of Coil	Interturn Test Voltage
Single stack coils	$\frac{V}{3} + 1000$
Multi stack coils where adjacent conductors in the width stack are connected in parallel	$\frac{V}{3} + 1000$
Multi stack coils with zig-zag series connections	$\frac{2V}{3} + 1000$
Multi stack coils with up/down series connections	$V + 1000$

Where V = System line voltage of the supply for which the coil is designed.

Earthed Neutral Systems

1806 When the earthed neutral system of generation and distribution is used, earthing is to be through a resistor. The resistor is to be such that earth fault current is limited to a value which is not greater than full load current of the largest generator on a switchboard section nor less than three times the minimum current required to operate any device protecting against earth faults.

1807 The high voltage test for equipment in an earthed neutral system is to be as required for medium voltage equipment in other sections of this Chapter.

1808 Generator neutrals may be connected in common provided that the third harmonic content of the waveform of each generator does not exceed 5 per cent.

1809 Where a switchboard is split into sections operated independently or where there are separate switchboards, an earthing resistor is to be provided for each section or for each switchboard.

Means are to be provided to ensure that the earth connection is not removed when generators are isolated.

1810 A means of isolation is to be fitted in the earthing connection of each generator so that generators can be completely isolated for maintenance.

1811 All earthing resistors are to be connected to the hull. In order to eliminate possible interference with radio, radar and communication circuits it is recommended that earthing resistors be bonded together on the hull side of the resistors, and that the means of bonding be separate from that provided by the ship's hull.

Protection

1812 In the earthed neutral system generators are to be provided with protection against internal faults. In the insulated neutral system internal fault protection is recommended.

1813 An efficient means of indicating any earth fault in the system is to be fitted. The indicator may be a low reading ammeter operating from a current transformer in the neutral or a leakage indicator or equivalent arrangements ensuring rapid automatic isolation.

1814 Any lower voltage system supplied through transformers from the high voltage system is to be earthed or, alternatively, adequate precautions are to be taken to prevent the low voltage system being charged by leakage from the high voltage system.

Cables, Conductors and Terminations

1815 High voltage cables may be installed:—

(*a*) In the open, e.g. on carrier plating, when they are to be provided with a continuous metallic sheath or armour which is effectively bonded to earth to reduce danger to personnel, or

(*b*) Contained in earthed metallic ducting or pipe when the cables may be as in (*a*) or the armour or metal sheath may be omitted. In the latter case care is to be taken to ensure that ducts or pipes are electrically continuous and that short lengths of cable are not left unprotected. Other cables are not to be run in the same ducts or pipes as high voltage cables.

1816 Where practicable, high voltage cables are not to be run through accommodation spaces.

1817 High voltage cables are to be segregated as far as practicable from cables operating at lower voltages.

1818 All high voltage cables are to be readily identifiable by suitable marking.

1819 When single core cables are used precautions are to be taken against circulating currents in the sheath or armour and the cables are to be transposed at intervals of about 50 feet (16 metres).

1820 All high voltage equipment is to be so designed and located that adequate space is provided to ensure efficient cable terminations.

1821 Wherever practicable all conductors are to be effectively covered with suitable insulating material. In terminal boxes if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating material.

Switchgear

1822 All circuit breakers are to be of the fully withdrawable type.

Machines

1823 A lower limit of 200 h.p. or kW is recommended for 3 kV machines and 400 h.p. or kW for 6 kV machines.

Section 19

LIGHTNING CONDUCTORS

General

1901 Lightning conductors are to be fitted to each mast of all wood, composite, and steel ships having wooden masts or topmasts. They need not be fitted to steel ships having steel masts.

Construction

1902 In wood and composite ships fitted with wooden masts, the lightning conductors are to be composed of continuous copper tape and/or rope, having a section not less than 0·15 square inch (100 sq. mm.) which are to be riveted with copper rivets or fastened with copper clamps to a suitable copper spike not less than 0·5 inch (13 mm.) in diameter, projecting at least 6 inches (150 mm.) above the top of the mast. Where tape is used the lower end of the tape is to terminate at the point at which the shrouds leave the mast, and is to be securely clamped to a copper rope of not less than 0·5 inch (13 mm.) diameter. This copper rope is to be led down the shrouds and is to be securely clamped to a copper plate not less than 2 square feet (0,2 sq. m.) in area, fixed well below the light waterline and attached to the ship's side in such a manner that it is to be immersed under all conditions of heel.

1903 In wood and composite ships fitted with steel masts, each mast is to be connected to a copper plate in accordance with 1902, the copper rope being securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

1904 In steel ships fitted with wooden masts, the lightning conductors are to be composed of copper tape or rope terminating in a spike, as set forth in 1902. At the lower end this copper tape or rope is to be securely clamped to the nearest metal forming part of the hull of the ship.

1905 Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type, and efficiently locked. No connection is to be dependent on a soldered joint.

1906 The resistance of the lightning conductor, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0·02 ohms.

Section 20

TRIALS

General

2001 Before a new installation, or any alteration or addition to an existing installation is put into service the following trials are to be carried out. These trials are in addition to any acceptance tests which may have been carried out at the manufacturers' works.

Insulation Resistance

2002 INSTRUMENTS—Insulation resistance is to be measured using a self-contained instrument such as a direct reading ohmmeter of the generator type applying a voltage of at least 500 V.

Where a circuit incorporates capacitors of more than two microfarads total capacitance, a constant-voltage type instrument is to be used to ensure accurate test readings.

(*a*) POWER AND LIGHTING CIRCUITS—The insulation resistance between all insulated poles and earth and, where practicable, between poles is to be at least 1 megohm.

The installation may be sub-divided and appliances may be disconnected if initial tests produce results less than this figure.

(*b*) INTERNAL COMMUNICATION CIRCUITS—Circuits operating at 50 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 megohm.

Circuits operating at less than 50 V are to have an insulation resistance of at least 0·33 megohm.

(*c*) SWITCHBOARDS, SECTION BOARDS AND DISTRIBUTION BOARDS—The insulation resistance is to be at least 1 megohm when measured between each busbar and earth and between busbars. This test may be made with all circuit-breakers and switches open and all fuse links for pilot lamps, earth fault-indicating lamps, volt-meters, etc., removed and voltage coils temporarily disconnected, where otherwise damage may result.

(*d*) GENERATORS AND MOTORS—The insulation resistance of generators and motors, in normal working condition and with all parts in place is to be measured and recorded.

The test should be carried out with the machine hot, if possible. The insulation resistance of generator and motor cables, field windings and control gear is to be at least 1 megohm.

Earth Continuity

2003 Tests are to be made to verify that all earth continuity conductors are effective and that the bonding and earthing of metallic conduit and/or sheathing of cables is effective.

Performance

2004 It is to be demonstrated that the Rules have been complied with in respect of :—

Satisfactory commutation and performance of each generator throughout a run at full rated load.

Temperatures of joints, connections, circuit-breakers and fuses.

The operation of engine governors, synchronizing devices, overspeed trips, reverse-current, reverse-power and over-current trips and other safety devices.

Voltage regulation of every generator when full rated load is suddenly thrown off.

For a.c. and d.c. generators, satisfactory parallel operation and kW load sharing of all generators capable of being operated in parallel at all loads up to normal sea or harbour working load. For a.c. generators satisfactory parallel operation and kVA load sharing of all generators capable of being operated in parallel at all loads up to normal sea or harbour working load.

All essential motors and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously for a sufficient length of time to demonstrate that they are satisfactory.

Propulsion equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction. The equipment is to have sufficient power for going astern to secure proper control of the ship in all normal circumstances. In passenger ships the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manœuvring conditions, and so bring the ship to rest from maximum ahead service speed is to be demonstrated at the sea trial.

Voltage Drop

2005 Voltage drop is to be measured, where necessary, to verify that this is not excessive. (*See* M 813.)

Section 21

SPARE GEAR

2101 The following articles of spare gear, so far as they are applicable, are to be carried. Items used are to be replaced or made good by the Owners as opportunity occurs.

2102 One set of brushes and one set of bearings for one machine for each size of generator and for each size of motor engaged on essential services, such as those indicated below :—

Air compressors for heavy oil engines.

Scavenge blowers.

Air pumps.

Ballast pumps.

Bilge pumps.

Circulating and cooling water pumps.

Condenser circulating pumps.

Extraction pumps.

Feed water pumps.

Fire pumps.

Fuel valve cooling pumps.

Lubricating oil pumps.

Oil fuel pumps and oil fuel burning units.

Cargo refrigerating motors, including compressors, brine pump, circulating pump, fans, etc.

Fans for forced draught to boilers.

Steering gear.

Windlasses.

Ventilating fans for engine room and boiler rooms.

Oil separators.

Steering Gear

2103 For each size of steering gear motor and motor-generator if no standby electrical machine is installed, the following spare gear is required in addition to the spares for motors enumerated above :—

(i) Direct-current machinery :—

1 spare armature of each size fitted complete with shaft and half coupling.

1 spare field coil of each type fitted.

(ii) Alternating-current machinery :—

1 spare stator complete of each size fitted.

Fans for Refrigerating Equipment

2104 For electrically-driven air circulating fans the following spare gear will be required, in addition to the spares enumerated in 2102 for each size of motor installed, except where a duplicate fan motor in accordance with N 370 is installed :—

1 motor complete, or

Direct-current machinery :—

1 armature complete.
1 complete set of field coils.
1 complete set of brush gear.
1 set of bearings.

Alternating-current machinery :—

1 stator complete.
1 set of bearings.

Control Gear

2105 For the starting gear of motors, such as those enumerated in 2102 :—

1 set of contacts which are subject to burning or wear.

1 set of springs.

10 per cent of each different resistance element, but at least one of each.

1 of each type of shunt coil used for contactors, relays or low voltage release.

For six or less starters in which these parts are interchangeable it will be sufficient to provide one set of spares for the starter employing the greatest number of parts.

Switchgear and Distribution Boards

2106 For each type of circuit-breaker on each pole :—

1 set of contacts which are subject to burning or wear.

1 set of parts subject to wear.

1 set of springs.

1 shunt trip coil and 1 resistance element, of each kind used.

15 per cent but not less than six of each type of cartridge or other non-renewable fuses.

Rewireable fuse-handles; 5 per cent, with a minimum of one, of each size or type used, provided that not more than 12 need be supplied.

Navigating and Signal Lights

2107 Navigating and signal lights and their pilot lamps for indicating devices :—

1 complete spare set of lamps.

Emergency Lighting

2108 Where supplied from storage batteries of a voltage different from the ship's circuit :—

1 complete spare set of lamps.

Electric Couplings

2109 For each size of electric coupling used for propulsion purposes, the following is required as a minimum :—

1 complete set of brush gear.

1 field coil of each type fitted.

1 set of brushes for one coupling.

1 gauge for checking the magnetic air gap.

Spares for the control gear and switchgear as above.

Propulsion Equipment

2110 Owing to the varied characteristics of equipment an exact list of spares cannot be specified but the following should be provided as a minimum :—

(*a*) Generators, Motors and Exciters—One set of bearing bushes, with oil rings, if used, of each size and type for the propulsion generators, motor and exciter.

Two lines of brush holders of each size and type.

One set of carbon brushes for one generator, exciter, and one motor.

One shunt field coil of each size and kind used for direct-current generators, exciter and motors.

One set of slip rings for one motor if of the alternating-current type.

(*b*) Switch and Control Gear

One set of contacts liable to burning or wear.

One set of springs.

10 per cent of each different resistance element, but at least one of each.

One of each type of shunt wound coil used for contactors, relays, or trip coils.

Two fuse handles of each type and size, or 15 per cent, but not less than six of each type of fuse.

16th June, 1966

RECOMMENDATIONS FOR ELECTRICAL EQUIPMENT

The following recommendations are for those features of the electrical installation which are not considered to be the concern of classification and therefore are not included in Chapter M. It should be clearly understood that these recommendations are not mandatory and are intended merely for the use of those Shipowners and Shipbuilders who may seek more guidance on equipment standards than is given in the Rules.

RECOMMENDATIONS FOR ELECTRICAL EQUIPMENT

Section 1

GENERAL

Earthing

Rule 108 The following items do not require to be earthed :—

(i) Lamp caps.

(ii) Shades, reflectors and guards supported on lighting fittings constructed of or shrouded in insulating material.

(iii) Metal parts or screws in, or through, insulating material which are thereby separated from current carrying parts in such a way that they cannot become live or come into contact with earthed parts.

(iv) Portable appliances having double insulation.

(v) Bearing housings which are insulated in order to prevent circulation of current in the bearings.

(vi) Clips for fluorescent lamps.

(vii) Cable clips.

(viii) Apparatus supplied at extra low voltage.

(ix) Fixed apparatus or parts of apparatus which, although not shrouded in insulating material is so guarded that it cannot be touched and cannot come in contact with exposed metal.

Section 2

SYSTEMS OF SUPPLY

It is recommended that in alternating current systems for socket outlets where special precautions against shock are necessary, e.g., portable boiler cleaning tools where the operator works in a confined space and his skin will be damp, the following maximum voltages should be used :—

(i) Supplied direct	55V
(ii) Where a safety isolating transformer is used supplying only one socket outlet	250V

Section 4

ROTATING MACHINERY

With the exception of machines for purely domestic purposes such as motors of vacuum cleaners, portable tools and galley equipment it is recommended that all machines comply with the requirements of M 4. Machines for domestic purposes should comply with a national or international standard.

Short Circuit

Sudden short circuit tests, when required by the purchaser, should be a matter for agreement between purchaser and manufacturer. If carried out they should be made at an initial terminal voltage not greater than the rated voltage of the machine and at rated frequency.

Field Regulation of Direct Current Generators

Rule M 417 This requirement will be met if at the conclusion of the full load temperature test, with full load current and normal full load voltage at the terminals when running at full load engine speed, the voltage across the shunt field regulator, with an ambient air temperature of 15° C., is not less than 14 per cent of the terminal voltage of the machine. This makes allowance for the difference in field resistance between average test conditions and the most severe service conditions.

Transient Voltage Response of Alternating Current Service Generators

Rule M 423 To meet this requirement it is recommended that one of the following alternatives be applied as determined by the characteristics of the installation, but such a test should not be required if evidence can be produced that a test has been carried out on a similar machine.

(a) When the starting kVA of the motors is 35 per cent or less of the capacity of the generating plant and where a rapid voltage recovery is not required.

With the generator driven at its rated speed at no load and giving its rated voltage under the control of the AVR, the maximum voltage change should not

exceed 15 per cent when a current equal to 35 per cent full load current at any power factor between zero and 0·4 lagging is suddenly drawn. The voltage should be restored to within 3 per cent of rated voltage in not more than 1·5 seconds.

(*b*) *When the starting kVA of the largest motor or group of motors liable to be started simultaneously exceeds 35 per cent but is less than 60 per cent of the capacity of the generating plant.*

With the generator driven at its rated speed at no load and giving its rated voltage under the control of the AVR the maximum voltage change should not exceed 15 per cent when a current equal to 60 per cent full load current at any power factor between zero and 0·4 lagging is suddenly drawn. The voltage should be restored to within 3 per cent of the rated voltage in not more than one second.

(*c*) *When the starting kVA of the largest motor or group of motors liable to be started simultaneously exceeds 60 per cent of the capacity of the generating plant, or when the recovery time of one second is not satisfactory for the operation of special devices supplied by the same generating plant.*

A specification of the performance of the generating plant should be agreed between purchaser and manufacturer.

Wattless Load Sharing

Rule M 425 This requirement may be otherwise stated:—

"When alternating current generators are operated in parallel the wattless loads of the individual generating sets should not differ from their proportionate share of the total wattless load by more than 10 per cent of the rated wattless output of the largest machine."

M 425 give a more convenient method of measuring wattless load sharing but other methods can be used, e.g., measurement of power factor.

Frequency

When running alternating current motors from a shore supply of lower frequency care should be taken to lower the terminal voltage at the motors in proportion to frequency in order not to overload the motors.

Section 5

DISTRIBUTION

It is recommended that in machinery spaces, large galleys and such spaces as corridors, stairways leading to boat decks and public rooms, lighting should be supplied from at least two final sub-circuits one of which could be the emergency circuit so that failure of one circuit does not reduce the lighting to an inadequate level.

Steering Gear

Where electric power is used for the operation of steering gear it is recommended that failure of supply be indicated by audible and visual alarms in the engine room and/or pilot house.

In any steering gear where electric control only is used it is recommended that the control be duplicated.

Section 6

SWITCHBOARDS, SWITCHGEAR AND PROTECTIVE EQUIPMENT

All main and emergency switchboards should be provided with handrails in front of the panel. Where the switchboard is of the open type the rail should be non-conducting. The platform in front of and behind switchboards should have a non-slip surface.

Where necessary insulated handrails should be fitted behind switchboards and passageways behind switchboards should be provided with access doors at each end, these to be capable of being opened from the passageway. The doors should bear a prominent and permanent notice giving the maximum voltage.

For voltages between poles or to earth exceeding 250V direct current or 55V alternating current, switchboards should be of the dead front type. Where the voltage exceeds 55V during operation an insulating mat should be provided.

Where an earth indicating system using either two or three lamps is used the lamps should be of metal filament type each not exceeding 30W. They should be of the same colour and placed not more than 6 in. apart.

For preference tripping systems the following overcurrent settings are recommended (expressed as a percentage of the rated current of the generator or circuit to be protected).

Main generator circuit breaker	150 per cent
Preference tripping relays	110 per cent

Time delays should be established in accordance with the nature of the load the following values being given as an example :—

First tripping circuit breaker	5 sec.
Second tripping circuit breaker	10 sec.
Third tripping circuit breaker	15 sec.
Main generator circuit breaker	20 sec.

For overloads less than 10 per cent protection may consist of an alarm signal operated by a time delayed relay set to approximately 110 per cent rated current of the generator.

Two-wire circuits of rating exceeding 100A should be controlled as a minimum in one insulated pole or phase by a switch. Three-wire alternating current circuits rated at more than 60A should be controlled by a triple-pole linked switch.

The minimum operating current of every circuit breaker should be not greater than twice the rating of the smallest conductor which it is installed to protect except for motor circuits where short circuit protection only is required (in these cases three times the cable rating).

The overcurrent setting of a circuit breaker will depend on individual arrangements and in motor circuits must be matched to the load temperature characteristics of the motor, the following figures being given merely as an example :—

	Overcurrent
Continuously rated circuits	25 per cent
Intermittently rated circuits	50 per cent
Steering gear and emergency circuits	200 per cent

Circuit breakers, contactors and switches should be so installed that, as far as practicable, their moving parts and associated relays are not live when the circuit breaker or contactor is in the OFF position.

Circuit breakers and contactors should be provided with a means of isolation.

In large installations, where fault levels are high, circuit breakers should be of the power operated type.

In earthed systems of large capacity, protection against internal faults in the generators should be considered.

All generators arranged for parallel operation with one another or with the shore power feeder should be provided with undervoltage release which prevents the closing of the appropriate circuit breaker until the generator terminal voltage reaches at least 70 per cent of the rated voltage.

The installation of automatic circuit opening devices, other than for short circuit protection, is not recommended in exciter circuits.

In alternating current systems consideration should be given to the fitting of an automatic trip to main generator circuit breakers which will open the breaker on loss of excitation.

The fitting of an ammeter in exciter circuits is recommended.

Selection of Fuses

(i) Fuses for steady load circuits, such as heating circuits, should be of current rating at least equal to that of the apparatus. If other overcurrent protection is provided or if discrimination requires it, a fuse of greater current rating may be necessary.

(ii) Fuses for fluctuating load circuits, such as motor circuits, transformer circuits, lighting circuits and capacitor circuits, should have a time/current characteristic which allows the transient overcurrent to be carried without operation of the fuse. It will sometimes be necessary to select fuses of a current rating greater than that of the circuit.

For motor circuits it will be necessary to obtain particulars of the magnitude and duration of the starting current and to select fuses by referring to the time/current characteristics.

Section 8

CABLES

In large installations where short circuit currents may be high it is recommended that cables are armoured and in three-phase installations, as far as is practicable three-core cables carrying the three-phase currents should be employed.

Where these precautions are necessary particular care should be taken with the cable supports especially at the ends of cables.

In 110V installations where lighting cables may be fully loaded, are bunched together and are installed between wooden panelling or similar locations it is recommended that the minimum size of conductor be not less than ·003 sq. in. (2,5 sq. mm.).

Section 10

LIGHTING

In bathrooms, galleys, laundries and similar places the parts of a lampholder likely to be touched should be constructed of or shrouded in insulating material and fitted with a protective shield or totally enclosed fittings should be used.

Lighting switches for bathrooms and similar locations should be outside such spaces unless they are of construction suitable for humid conditions.

Lamps which are used near combustible material should be installed in totally enclosed fittings.

Where tubular fluorescent lighting is used, lighting by one or more filament lamps should be provided, especially in compartments containing running machinery.

Lamps which are used in spaces liable to contain explosive or inflammable materials should be installed in flameproof fittings.

Filament lamps are recommended for emergency lighting.

Live parts of fluorescent lighting installations should be screened with earthed metal or insulating material.

Connections to Lighting Fittings

Due to the reduced physical sizes of lamps in many countries, e.g., 100W lamps can now be installed in many fittings that previously were designed for 60W lamps care must be taken with cable connections so that the maximum conductor temperature is not exceeded. Tests carried out in the past have shown a temperature rise at some lampholder terminals of 80° C. and a distance about 0·625 in. (16 mm.) from the lampholder terminals exhibited a temperature rise of 60° C.

Where cables operate at temperatures in excess of the permitted maximum, deterioration of the insulation occurs with premature failure in service.

Comments on the behaviour of the various classes of insulation are given below :—

(*a*) Rubber

Maximum conductor temperature 60° C. At higher temperatures it ages with increasing severity, reducing its life.

(*b*) Polyvinyl Chloride

Maximum conductor temperature 60° C. At higher temperatures it may flow away from the conductor when under pressure, e.g., clips.

(*c*) Polychloroprene

This is usually associated with rubber when maximum conductor temperature is 60° C. At higher temperatures it absorbs moisture after cooling leading to electrical breakdown.

(*d*) Butyl

Maximum conductor temperature 80° C. At 130° C. it ages rapidly and may turn into a powder which can fall away from the conductor if subject to vibration or shock.

(*e*) Silicone Rubber

Maximum conductor temperature 150° C. and intermittently up to 200° C.

Fittings should be designed so that the maximum permitted temperature for the cable is not exceeded. Alternatively high temperature tails (e.g., silicone rubber) should be incorporated in the fitting and led to a terminal block.

Section 11

ACCESSORIES

Where differing distribution systems are used any socket outlets and plugs should be of such design that incorrect connection cannot be made.

In general socket outlets should not be fitted in bathrooms, lavatories and similar wet places.

In systems at 110V direct current and above or 55V alternating current and above socket outlets and plugs should be provided with an earthing contact. This contact should make contact before the live pins when the plug is inserted.

Heating and Cooking Equipment

Electric heating and cooking equipment should be so constructed that parts which must be handled cannot exceed 55° C.

Heating elements should be readily replaceable.

Connections between elements, switches and supply cables should be carried out with terminals.

Connections between elements and between elements and terminals to which insulated cables may be connected, unless self-supporting and rigidly secured in position should be continuously insulated with incombustible material.

Heating elements should be suitably guarded. Live parts of cooking appliances should be protected so that cooking utensils cannot come into contact with them.

Space heaters in cabins, lockers, etc., should be of the convector type. Space heaters should not be installed in spaces where inflammable gases might accumulate.

Batteries

Batteries should be located where they are not exposed to excessive heat or extreme cold. Batteries for emergency service, including emergency diesel engine starting should be located above the bulkhead deck. The best operating conditions for batteries are obtained when the working temperature is between 15° C. and 27° C. Where practicable the temperature of the electrolyte should not be permitted to exceed 50° C. since higher temperatures tend to reduce the life of the battery. Low temperatures may temporarily reduce the capacity of the battery.

Mechanical ventilation of battery rooms should be capable of changing the air in the battery room four or five times per hour.

Spare Gear

The provision of an insulation tester is recommended.

Section 16

SPECIAL REQUIREMENTS FOR OIL TANKERS

Flameproof and Intrinsically Safe Equipment

It is sometimes stated that flameproof equipment should be permitted in dangerous spaces, e.g., cargo pump rooms, but this cannot be agreed except as stated in Section 16. Flameproof equipment is flameproof when it leaves the manufacturers' works and after a period of service may no longer be flameproof, due to faulty or inadequate maintenance.

Flameproof lighting fittings are permitted in pump rooms, only because many pump rooms are so large that they cannot be adequately lit through glazed ports.

Intrinsically safe equipment and the circuit to which it belongs is to be physically separated from all other circuits. This is because the certificate of intrinsic safety involves both the equipment and its circuit.

Chapter N

REFRIGERATED CARGO INSTALLATIONS

Extract from Chapter B for reference

B 901 On application from Owners, refrigerated cargo installations which comply with Chapter N of the Rules and are favourably reported on by the Surveyors will be assigned an appropriate class in accordance with N 1. Certificates will be issued and the class notation, together with the particulars of the installation, will be entered in the Supplement.

B 902 The class assigned will be retained provided the installation is found to be in a good and efficient condition at the Periodical, Loading Port, and other Surveys set forth in N 8.

B 903 The paragraphs in B 14 regarding Withdrawal of Class and in B15 regarding Reclassification, apply also to Refrigerated Cargo Installations.

Section 1

GENERAL

Class Notation

101 The class notation assigned will be Lloyd's RMC followed by the minimum temperature(s) approved by the Committee for the installation with the maximum sea temperature stated, e.g. "to maintain temp. 10° F. in the lower and 31° F. in the upper chamber with sea temperature 85° F. maximum."

NOTE.—The temperature at which the cargo is to be carried is not the responsibility of the Society.

102 Installations constructed under the Society's Special Survey in accordance with N 2 to N 6 will be eligible for the distinguishing mark ✠ before the class notation, thus ✠Lloyd's RMC. In other cases the mark ✠ will not be assigned.

103 In the case of installations designed to reduce the temperature of non-precooled cargoes a mark ‡ will be shown under the class notation in the Appendix to the Register Book and will be included on the certificate as an indication that an installation has been considered by the Society for this duty. A special statement showing the cargo cooling capabilities of such installations, in respect of stated weights and descriptions of cargoes under stated conditions, will be issued on application by the Owners to the Society's Head Office.

Special Cases

104 The Committee will be prepared to give consideration to cases of ships engaged on voyages of short duration, to installations of small capacity, or to other special circumstances. In such cases the class may include a service limitation or other restriction.

Refrigerants

105 These Rules are applicable to the following primary refrigerants:—

Carbon Dioxide
Ammonia
Dichlorodifluoromethane
Monochlorodifluoromethane

Proposals to use other refrigerants will be specially considered on application, but methyl chloride will not be accepted.

NEW INSTALLATIONS

Section 2

SPECIAL SURVEY DURING CONSTRUCTION

201 New installations intended for classification are to be constructed under the Society's Special Survey in accordance with the requirements of N 3 and N 4; tests are to be carried out as specified in N 5, and spare gear is to be supplied as listed in N 6.

Information and Plans to be Submitted

202 The following information and plans are to be forwarded for consideration before construction is commenced :—

(*a*) Refrigerating plant—standard data sheet in duplicate. (Copies of this data sheet may be obtained from the Society's local office.)

(*b*) Refrigerating plant—detailed specification in triplicate.

(*c*) Insulation—detailed specification in triplicate.

(*d*) General arrangement of insulated chambers in elevation and plan. The plans are to be to a scale of not less than 1:50 and adequate for the measurement of the external

surfaces and the deck and bulkhead edges. Dimensions and spacing of frames, beams and stiffeners and details of other steel work protruding into the insulation and within the chambers are to be shown. Oil fuel and liquid cargo tanks adjacent to or below the chambers are to be indicated, and whether heating is provided for such tanks. Ventilating and air conditioning trunks and ducts passing through chambers are to be shown. The plans should include a diagram showing the position of the chambers in relation to other parts of the ship if this is not otherwise apparent.

(*e*) Detailed plans showing the thickness and methods of attachment of the insulation and linings on all surfaces, including girders, hatch coamings and pillars; details of insulated doors, and hatch, access, bilge and manhole plugs and their frames. Method of attachment of brine or direct expansion grids and meat rails are also to be shown.

(*f*) Arrangement of air ducts (including method of cooling spaces within hatch coamings), air coolers, fans and their motors.

(*g*) Air cooler defrosting arrangements, other than hot brine circulating systems.

(*h*) Arrangement of brine grids including those in way of hatches; and method of construction.

(*i*) Arrangement of chamber thermometers.

(*j*) General arrangement of refrigerating machinery.

(*k*) Brine circuit diagram with particulars of piping.

(*l*) Primary refrigerant gas and liquid circuit diagrams and full particulars of all pressure piping.

(*m*) Sectional arrangement of refrigerant compressors.

Detailed dimensioned plans of :—

(*n*) Compressor crank shafts.

(*o*) Compressor crank cases where exposed to the refrigerant pressure.

(*p*) Condensers.

(*q*) Evaporators (brine coolers).

(*r*) Air coolers.

(*s*) Oil separators.

(*t*) Liquid receivers.

(*u*) All other pressure vessels.

NOTE.—All the plans listed, and any others which may be specially requested are to be forwarded in triplicate.

(*v*) Similar plans are required for refrigerating plant of other designs.

(*w*) Where the refrigerating machines are driven by oil engines particulars and plans are to be submitted in accordance with the requirements of G 104 and H 7.

(*x*) Where the refrigerating machines or air cooler fans are driven by steam engines particulars and plans are to be submitted in accordance with G 104.

(*y*) Where air cooler or necessary air stirring fans are electrically driven plans of the motors are to be submitted in accordance with M 429.

(*z*) Where it is proposed to apply centralised, bridge or automatic controls, a description of the scheme and particulars of the spares to be carried are to be submitted.

Refrigeration required in excess of N 306

203 Refrigeration required in excess of that specified in N 306, which may be necessary for rapid cooling of chambers, or cooling cargoes loaded at temperatures above the carrying temperature, is to be in accordance with a specification approved by the Owners.

Rate of Air Circulation

204 Where refrigeration is effected by forced air circulation over coolers the proposed fan output in each chamber will be considered in relation to the heat to be removed, the nature of the cargo and the service(s) intended.

Where chambers are intended for the additional duties mentioned in 203 the rate of air circulation is to be in accordance with the Owners' requirements.

Subsequent Modifications or Additions

205 Any subsequent modifications or additions to particulars and/or arrangements shown on the approved plans or in the specifications are also to be submitted for approval.

Novel Arrangement and Designs

206 Where the proposed construction of the refrigerating plant or refrigerated chambers is novel in design or involves the use of unusual material, special tests may be required, and a suitable class notation may be assigned when the Committee consider this necessary.

Survey Requirements

207 From the commencement of the construction and installation of the refrigerating plant and of the insulation and fitting out of the cargo chambers, to the testing of the completed installation, the Surveyors are to examine the materials and workmanship and are to indicate at the earliest opportunity and require the rectification of any items not in accordance with the Rules or the approved specifications and plans, or any material, workmanship or arrangement found to be defective or unsatisfactory.

Section 3

REFRIGERATING PLANT

Definition of a Unit

301 A refrigerating unit comprises a prime mover, one or more refrigerating machines (refrigerant gas compressors), one gas condenser—and in the case of a secondary refrigerant, one brine cooler (gas evaporator)—and the fittings necessary to permit independent operation of the unit.

302 If the prime mover of a refrigerating machine is a steam engine with two or more cylinders and each cylinder drives a corresponding compressor, or there is more than one motor similarly arranged, and if each compressor is connected to its own condenser and brine cooler (where fitted), the arrangement is to be regarded as two or more units as the case may be, provided the units can be used separately or in combination.

NOTE.– Condensers or evaporators of the coil-in-casing type need not necessarily be in separate casings.

303 Two or more refrigerating machines (or compressors) driven by a single prime mover, or having only one condenser or one brine cooler (where fitted), are to be regarded as one unit.

304 Where a refrigerating plant is provided for sub-cooling the liquid refrigerant, or cooling the condensers of other refrigerating machines, and is not arranged for cooling the cargo spaces independently, it will not be regarded as a unit.

305 Where a refrigerating plant is dependent on the main refrigerating units for cooling the condenser or the refrigerant liquid, it will not be regarded as a unit.

Refrigeration to be Provided

306 The refrigeration provided is to be capable of efficiently maintaining the minimum temperature(s) under the conditions applicable to the maximum sea temperature for which approval by the Committee is desired and which is to be specified in the class notation (*see* N 101), when working 24 hours a day with any one of the refrigerating units out of action. It is recommended that a reasonable margin in plant output over maximum load be allowed for possible overall inefficiencies under service conditions.

307 Where part of the necessary refrigeration is obtained by the sub-cooling of the liquid refrigerant by other refrigerating plant, one plant supplying such sub-cooling may be considered sufficient provided the refrigerating units including the stand-by unit are capable of the full duty specified in 306 in the event of the sub-cooling plant being out of action.

308 In any case where all the refrigerating units are not connected for use on all the refrigerated cargo chambers the plant serving each chamber is to comply with the requirements of 306.

309 The foregoing requirements are based on the assumption that installations will have relatively few refrigerating units each arranged to serve all chambers. In the case of installations having a large number of small units arranged to serve individual chambers, or groups of chambers, the question of reserve plant will be the subject of special consideration.

Number of Refrigerating Units

310 Not less than two complete refrigerating units are to be fitted. Where two units only are fitted the working parts are to be interchangeable.

Stand-by Pumps

311 A stand-by gas condenser cooling water pump is to be installed ready for use in addition to the pumps required for the full duty specified in 306. This stand-by pump may be one of the pumps used for other purposes provided it is of adequate capacity and its use on the gas condenser does not interfere with other essential services.

312 Where brine is used for refrigerating the cargo chambers a stand-by brine circulating pump is to be installed ready for use in addition to the pumps required for the full duty specified in 306.

Sea Connections

313 Condenser cooling water is to be taken from not less than two sea connections, one of which may be that provided for other purposes, such as the water ballast inlet. It is recommended that one of the sea connections be provided on the port and the other on the starboard side.

Location of Machinery

314 Where ammonia refrigerant is used the refrigerating machinery is to be in an efficiently ventilated compartment isolated from the propelling machinery spaces and shaft tunnels, and living quarters.

Machinery using non-toxic and non-inflammable refrigerants will not be subject to restriction on location in general, but proposals to install relatively large plants in propelling machinery spaces will require special consideration.

Prime Movers

315 Where refrigerating plant is electrically driven the motors and their control gear are to comply with the requirements of M 4 and M 7.

316 Where the refrigerating machinery is steam driven the steam engines are to comply with the requirements of Chapters G and H and the exhaust steam is to be led to the main and auxiliary condensers.

317 Where the refrigerating machinery is driven by oil engines the requirements of Chapters G and H are to be carried out.

Motive Power

318 In the case of 315 the electric power is to be taken from at least two generators (*see also* M 403) and in the case of 316 steam is to be taken from at least two boilers, each capable of the maximum duty without interference with other essential services.

Plant on Ships not classed with the Society

319 In the case of refrigerating installations being constructed under the Society's Special Survey on ships not intended to be classed with this Society, the generator engines and electrical equipment, which supply power to the refrigerating installations, should be constructed in accordance with the requirements of the Classification Society concerned, but such plant is to be examined generally and under working conditions.

Steel Castings

320 Important steel castings are to comply with the requirements of P 5.

Steel Forgings

321 Crank shafts and other important steel forgings are to comply with the requirements of P 6.

Dimensions of Crank Shafts

322 Crank shafts of single acting reciprocating refrigerant compressors, of mild steel having a tensile breaking strength of 44-50 kg. per mm.^{2} are to have dimensions not less than those calculated from the following formulæ.

Where crank shafts are proposed to be made of steel of greater strength or of other material, the particulars including the material specification are to be submitted for special consideration.

323 The formulæ are applicable to compressors operating on the normal cycle, with crank shafts having one, two, three or four cranks at equal angles and one cylinder acting on each, and with two or more main bearings.

324 The formulæ are also applicable to compressors, other than CO_2 having the crank and cylinder arrangements as shown in the following table, but in these cases the calculated shaft diameter is to be increased by 5%, 18% and 25% when the angle between cylinders is 90°, 60° and 45° respectively.

Number of crank pins	Number of cylinders per crank	Angle between cylinders
1 or 2	2	45°, 60° or 90°
3	2	45° or 60°
4	2	45° or 60°
1	3	45°, 60° or 90°
2	3	45° or 60°
3	3	45°
1	4	45° or 60°
2	4	45°

325 The formulæ are not applicable to crank shafts having more than one crank on the same top centre, or to compressors where the cylinders are arranged for supercharging by gas of higher pressure at an intermediate stage of the stroke.

Diameter of Crank Shafts

326

Refrigerant	Diameter of crank shaft (All dimensions in inches or millimetres)
Carbon Dioxide (CO_2)	$\sqrt[3]{\dfrac{D^2\left(15\dfrac{ab}{a+b}+1{,}25S\right)}{12}}$ for gas discharge pressures up to 105 kg. per cm.^{2}
Ammonia (NH_3) Monochlorodifluoromethane ($CH\,Cl\,F_2$)	$\sqrt[3]{\dfrac{D^2\left(2{,}5\dfrac{ab}{a+b}+0{,}15S\right)}{12}}$ for gas discharge pressures up to 17,5 kg. per cm.^{2}
Dichlorodifluoromethane ($C\,Cl_2\,F_2$)	$\sqrt[3]{\dfrac{D^2\left(1{,}5\dfrac{ab}{a+b}+0{,}1S\right)}{12}}$ for gas discharge pressures up to 10,5 kg. per cm.^{2}

where D = cylinder diameter,

S = length of stroke,

a = distance from the inner edge of one bearing to the centre line of the crankpin nearest the centre of the span,

b = distance from the centre line of the same crankpin to the inner edge of the other bearing,

a + b = distance (or span) between the inner edges of adjacent main bearings.

327 Where it is proposed to make solid forged crank shafts of steel having a specified minimum tensile strength greater than 44 kg. per mm.^{2}, but not exceeding 80 kg. per mm.^{2}, the diameter of the crank shaft is not to be less than given by the following formula:—

$$\text{Diameter of crank shaft in millimetres} = d \times \sqrt[3]{\frac{44}{0{,}72T + 12{,}6}}$$

where d = diameter, in millimetres, of crank shaft made of steel having a specified minimum tensile strength of 44 kg. per mm.^{2} as required by 326,

T = proposed specified minimum tensile strength in kg. per mm.^{2}

Crank Webs

328 Crank webs are to be of the following proportions or of equivalent strength :—

Breadth of web = 1,33 × calculated shaft diameter

Thickness of web adjacent to a bearing = 0,56 × calculated shaft diameter

Thickness of intermediate webs = 0,75 × calculated shaft diameter

CAST IRON CRANK SHAFTS

General

329 Where it is proposed to make crank shafts of cast iron, the material specification and the dimensions of the shaft are to be submitted for special consideration.

Material

330 The material specification should state the type of cast iron, the heat treatment, and mechanical properties, including the specified minimum tensile strength appropriate to the section of the crank shaft casting.

331 Any suitable type of high duty cast iron may be used, provided the minimum specified tensile strength is between 32 and 76 kg. per mm.^{2} Crank shafts are to be cast at a foundry approved for the production of cast iron crank shafts. (*See* P 19).

Crank Shafts

332 The diameter of the crank shaft is not to be less than that given by the following formula:—

$$\text{Diameter of crank shaft in millimetres} = d \times \sqrt[3]{\frac{22}{0{,}3T + 7{,}9 - \frac{d}{48}}}$$

where d = diameter in millimetres required by 326 for a steel crank shaft having a tensile strength of 44 kg. per mm.^{2}

T = specified minimum tensile strength of cast iron in kg. per mm.^{2} which is not to be less than 32 kg. per mm.^{2}

333 Special consideration will be given to crank shafts which have been designed and developed for optimum fatigue strength with cranks of the most favourable shape, and some allowance made for the superior strength thereby obtained. Particulars of any relevant tests or experience should be submitted.

Crank Webs

334 The proportions of the crank webs are to be as stated in 328.

Fillets and Oil Holes

335 Fillets at the junctions of crank webs with crank pins or journals are to be machined to a radius of not less than 5 per cent of the diameter of the crank shaft and are to have a smooth finish.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

Crank Shafts for Compressors of Other Designs

336 The particulars of crank shafts for double acting or compound compressors, and for other refrigerants or arrangements, are to be submitted for special consideration.

Maximum Working Pressures

337 The components of primary refrigerant pressure systems including piping, stop valves and headers are to be designed for a maximum working pressure of not less than :—

105 kg. per cm.^{2} for carbon dioxide (CO_2)

17,5 kg. per cm.^{2} for ammonia (NH_3) and monochlorodifluoromethane ($CH\,Cl\,F_2$)

10,5 kg. per cm.^{2} for dichlorodifluoromethane ($C\,Cl_2\,F_2$)

In the case of crankcases which are exposed to the refrigerant pressure the design pressure is to be not less than :—

14 kg. per cm.^{2} for ammonia and monochlorodifluoromethane

7 kg. per cm.^{2} for dichlorodifluoromethane

Crankcases designed for a lower pressure are to be provided with a pressure relief valve arranged to lift at the design pressure and the discharge led to a safe place.

If desired a lower design pressure may be considered for other parts of the low pressure side of the system.

The design pressure for other refrigerants which may be proposed will be considered on application, but as a general guide this will be the saturated vapour pressure at 46° C.

Refrigerant Pressure Vessels

338 Welded cylindrical pressure vessels which are of steel construction and exposed to the pressure of the refrigerant are to be constructed in accordance with the requirements of J 18 to J 23 so far as applicable, except that the pressure tests are to comply with 346.

339 Where ammonia is the refrigerant, pressure vessels are to be constructed to not less than Class 2 fusion welded or Class 1 forge welded requirements.

340 Where pressure vessel shells are made of steel tube the tubes are to comply with the requirements of E 5 so far as applicable, except that the formula for determining the thickness of straight shells may be modified to

$$t = \left(\frac{WP \times D}{2f} + 0{,}75\right) 1{,}15$$

341 Where ammonia is the refrigerant, pressure vessel shells are not to be manufactured from lap welded pipes.

342 Where pressure vessels are of seamless construction, they are to comply with the requirements of J 2405 to J 2407, and the pressure tests are to comply with 346.

343 Where it is proposed to construct pressure vessels of materials other than steel, or not of cylindrical form, full particulars will be required for special consideration.

Pressure Pipes

344 Steel piping for primary refrigerants is to comply with the requirements of E 5 except that the figure of 1,25 may be reduced to 0,75 and the pressure tests are to be in accordance with 346.

Butt welding of pipe lengths in lieu of flanged joints is to be carried out as required in E 5 under the supervision and to the satisfaction of the Surveyors.

Where the pipes are galvanized, a short part at the ends about 100 mm. long, is either to be left ungalvanized or the galvanizing is to be removed before welding.

345 Where it is proposed to use pipes of materials other than steel, full particulars are to be submitted for consideration.

Pressure Tests

346 The pressure tests which follow are to be witnessed by the Society's Surveyors at the makers' works. The hydraulic test may be carried out with any suitable liquid. When it is inconvenient to test the large NH_3 (ammonia) condensers and evaporators by submersion in water the shells may be charged with air and gas, and tested by some suitable means. In the case of $C\,Cl_2\,F_2$ (dichlorodifluoromethane) and $CH\,Cl\,F_2$ (monochlorodifluoromethane) a suitable gas may be used in lieu of air.

Refrigerant	Component	Minimum Test Pressure kg./cm.²	
		Hydraulic	Air*
CO_2	Compressor cylinder blocks, stop valves and connections, connecting piping, separators, condenser and evaporator coils and all components subject to gas pressure.	210	105
NH_3 and $CH\,Cl\,F_2$	Compressor cylinders, stop valves, connections and all piping.	42	21
	Compressor crankcases subject to refrigerant pressure.	21	10,5
	Condenser, evaporator and air cooler coils.	105	35
	Condenser and evaporator coils or grids welded to headers; condensers and evaporators of double pipe or "shell and tube" types; pressure vessels, and all other components subject to gas pressure.	35	17,5
$C\,Cl\,F_2$	Crankcases subject to refrigerant pressure.	14	10,5
	Small machines with cylinders up to 11,5 cm. dia. where the cylinders and crankcases are in one casting.	21	14
	All other components in the entire system, including piping.	24,5	14
	Cooling liquid side of refrigerant condensers.	2WP but not less than 1.	
Brine	Air cooler coil assembly.	7	
	Cast iron casings of refrigerant evaporators.	2WP but not less than 1.	
	Steel casings of refrigerant evaporators on suction side of pump.	2 × head pressure but not less than 2	
	Steel casings of refrigerant evaporator on discharge side of pump.	2WP but not less than 3,5	
	Open casings of brine evaporators.	Filled to top	

*Component submerged in water at 32° C.

Tests after Erection on Board Ship

347 Carbon dioxide systems are to be examined for gas leaks when the system is charged. Ammonia and monochlorodifluoromethane systems are to be tested to a gas or air pressure of not less than 14 kg. per cm.²

Dichlorodifluoromethane systems are to be tested by a suitable gas to a pressure of not less than 7 kg. per cm.²

Brine systems are to be tested to a hydraulic pressure of double the working pressure but not less than 3,5 kg. per

cm.^{2} Where the hydraulic test is not reasonably possible, sections of brine leads (service pipes) which have to be insulated before the circuits are complete may be tested by an air pressure of 6 kg. per cm.^{2}

Oil Separators

348 Suitable oil separators with drains are to be provided to the refrigerant lines. If wire gauze is used in the separator it is to be sufficiently robust and supported to prevent disintegration.

Filters (strainers)

349 Suitable filters are to be provided in the refrigerant gas lines to compressors and in the liquid lines to the regulators. Wire gauze in filters is to be sufficiently robust and supported to prevent disintegration. A filter may be combined with the oil separator required by 348.

Refrigerant Driers

350 Driers are to be fitted in monochlorodifluoromethane and dichlorodifluoromethane refrigerant systems, and the arrangement is to be such that the drier can be by-passed, isolated and opened up without interrupting plant operation.

Brine Systems

351 Where brine is the cooling medium it is recommended that the "closed" system with a brine balance tank be adopted in every case.

Safety Devices

352 A pressure relief valve and/or safety disc is to be fitted between each compressor and its gas delivery stop valve, the discharge being led to the suction side of the compressor.

353 All pressure vessels of refrigerant systems which could become filled with liquid refrigerant and isolated are to be provided with safety discs and relief valves in series, or other approved arrangements, the discharge being led to a safe place above deck.

354 Suitable spring-loaded safety valves are to be provided to the cooling liquid side of condensers and the brine side of evaporators where the pressure from any pump connected could cause a pressure in excess of the maximum working pressure.

Access to Plant

355 The arrangements are to be such that all components of the refrigerating machinery can be readily opened up for inspection or overhaul. Space is to be provided for the withdrawal and renewal of the tubes in "shell and tube" type evaporators (brine coolers) and condensers.

356 Where the coils of "coil-in-casing" type evaporators (brine coolers) and condensers are unwieldy and cannot readily be withdrawn, two suitably arranged inspection holes are to be provided in the top plate, in the sides at about half height and in the sides at the bottom. The holes are to be as large as practicable and not less than 230 mm. $\times$ 150 mm.

Manual Control

357 Where plants are operated by thermostatic refrigerant control, efficient manual controls are also to be provided, and the arrangement is to be such that thermostatic controls can be by-passed and isolated.

Refrigerating Plant of Other Design

358 Particulars of refrigerating plant of designs other than those mentioned in these Rules (e.g. steam jet vacuum refrigeration plants) are to be submitted for special consideration.

Cooling Appliances in Refrigerated Chambers

359 Chambers may be refrigerated by pipe grids on the ceiling and sides or by the circulation of air over coolers.

360 Refrigeration by pipe grids in the chamber is to be effected by the circulation of brine, except in the case of installations or chambers of very small capacity when the direct expansion of the refrigerant will be considered. The pipe grids in each chamber are to be arranged in not less than two sections. Each section is to be fitted with valves or cocks so that it can be shut off.

361 Either brine or the direct expansion of the refrigerant may be employed in the coils of air coolers. The coils are to be arranged in not less than two sections each of which is to be capable of being readily isolated when necessary.

362 The brine or direct expansion leads to, and returns from, the cooling appliances in each chamber are preferably to be in duplicate.

363 In order to minimise the dehydration of the cargo and the frosting of the cooling elements, it is recommended that the cooling appliances in each chamber should be designed to maintain the required minimum temperature under the maximum difference of not more than 4,5° C. between the cooling medium and the chamber.

364 Where the joints of brine pipes are made by screwed couplings, the pipes, coupling and back nut threads

are to be a good fit and the thickness of the pipes at the bottom of the screw thread is to be not less than 2,5 mm.

365 Where the joints of air cooler and grid piping are butt welded they are to comply with 344.

366 Steel brine and refrigerant piping, grids, joint sleeves and coils within the refrigerated cargo chambers, or where embedded in insulation, or individually insulated are to be galvanized externally. Where such pipes are connected by screwed couplings or by butt welds, the screw threads clear of the couplings or the butt welds and the adjoining ungalvanised portions of the piping, are to be suitably coated and taped after pressure testing to prevent corrosion. The locations of the joints are to be marked on the outside of the insulation.

367 Brine tanks and piping should not be galvanized on the brine side. In cases where any parts of the brine system are so treated, the brine cooling and return tanks, if closed, are to be provided with a ventilating pipe or pipes led to the atmosphere in a location where no damage will arise from the gas discharged, and the ventilating pipes are to be fitted with wire gauze diaphragms which can readily be removed. Where the brine tanks are not closed, the compartments in which they are situated are to be efficiently ventilated.

368 Means are to be provided for defrosting air coolers.

369 Air coolers are to be provided with trays of suitable depth arranged to collect all water condensate. The trays are to be provided with drains at the bottom so that the whole of the condensate can be drained away when the chambers are in service.

370 Access arrangements to air cooler fans and fan motors are to be such that both fans and motors may be readily removed for repair or renewal when the chambers are loaded with refrigerated cargo. Access for servicing only is required in cases where duplicate fans and motors, each capable of the full duty, are installed ready for use; this also applies to centrifugal type fans but not to their motors.

371 The air circulation system is to be arranged for positive air delivery to, or suction from, all parts of the chamber, including any space within hatch coamings.

372 Where it is intended to carry fruit cargoes which may be adversely affected by low temperatures, into sea areas where the temperature may be below the carrying temperature, facilities for heating the chambers are to be provided.

Air Refreshing Arrangements

373 Where chambers are intended for the carriage of gas-generating cargoes, air refreshing appliances are to be provided.

The position of the air inlets is to be carefully selected to minimize the possibility of vitiated air from any source entering the chambers. Each chamber is to be provided with individual inlets and discharges, having airtight closing appliances.

Section 4

CARGO CHAMBERS

Construction

401 Each individual chamber is to be of steel construction throughout and hose-tested for tightness, or tested more thoroughly by gas and air under slight pressure when required by the Owners.

402 At the request of Owners, special consideration will be given to the construction of divisional bulkheads of materials other than steel, between refrigerated cargo chambers where the chambers concerned are intended for cargoes which will not taint or otherwise adversely affect the cargo in any other chamber.

NOTE.—Gases given off by one description of fruit may adversely affect other descriptions by promoting rapid ripening.

403 Hatch plugs and their supports, chamber, air cooler and other access doors, tonnage openings, bilge limbers and plugs are to be made as airtight as possible.

404 Ventilators, ducts or pipes passing through refrigerated chambers to other compartments are to be made airtight and efficiently insulated. Ventilators to refrigerated spaces, if fitted, are to be provided with airtight closing appliances.

Airtightness of the Bulkheads and Decks

405 Where refrigeration pipes pass through bulkheads or decks of refrigerated cargo chambers they are not to be in direct contact with the steelwork, the holes through which they pass are to be true and of suitable finish for effectively sealing by the method intended. It is recommended that holes be trepanned and not burnt out. The airtightness of the bulkheads and decks is to be maintained (*see also* 408 and 413).

Airtightness of Chambers

406 The foregoing paragraphs, 401 to 405, are mainly concerned with infiltration of odours, gases, water vapour and air, which may taint or adversely affect the refrigerated cargo or the insulation, or cause undesirable frosting of cooling equipment. With this object in view it is also

recommended that insulation lining, bilge limbers and plugs, hatch plugs, chamber and access doors be constructed of water vapour-resisting material, or covered with such material, and sealed, where exposed to bilges or external conditions.

Insulation

407 Steelwork is to be thoroughly cleaned and coated in accordance with D 3003 and D 3004 and is to be examined for airtightness of fittings before insulation is applied.

Insulating material approved by the Committee is to be used throughout, and the thickness of insulation over all surfaces and the manner in which it is supported are to be in accordance with the approved specification and plans.

The insulation is to be efficiently packed and, where it is of slab form, the joints are to be butted closely together and staggered, unavoidable crevices being filled with insulating material. Bitumen should not be used for filling crevices.

408 Pipes carrying the refrigerating medium are not to be in contact with the steel structure and are to be effectively insulated outside the chambers they serve, except within insulated brine cooler and control rooms (*see also* 405 and 413).

Cross-references

409 For insulation of oil storage tank tops and bulkheads, *see* E 345 and E 346.

For pipes in refrigerated spaces, *see* E 416 to E 418.

For drainage of refrigerated spaces and cooler trays, *see* E 211 to E 216.

For use of fork lift trucks in refrigerated spaces, *see* D 1108.

Protection of Insulation

410 The insulation in way of the hatchways and about 0,6 metres beyond on the tank top and the tunnel top is to be protected with hardwood sheathing about 50 mm. thick, or to have similar protection.

Access Plugs and Panels

411 Insulated plugs are to be provided in the insulation where required for easy access to the bilges, bilge suction roses, cooler and space drains and tank manhole doors. Removable panels are to be provided for access to tank air and sounding pipes and drains.

It is recommended that, where no air space is provided below the insulation on the tank tops and the floor covering above the insulation is reinforced asphalt, a number of small insulated inspection plugs be fitted for leakage detection.

Where "loose fill" insulation is fitted and lined with metal it is recommended that airtight inspection plates be provided at the top of vertical surfaces to facilitate inspection and making good any settlement.

Fire-resisting Insulation

412 The insulation in way of coal bunkers and of any surfaces exposed to excessive heat is to be of approved fire-resisting material. Where wood grounds are used for supporting insulation, asbestos strips are to be fitted between the wood grounds and the steelwork to which they are attached.

Where pipes carrying the refrigerating medium pass through bunkers the pipes may be packed with granulated cork but there is to be a thick outer covering of fire-resisting material and the whole is to be protected by steel plates which are to be sealed for airtightness.

Watertight Bulkhead Fittings

413 Where cooling pipes pass through watertight deck plating and bulkheads, the pipes are not to be in contact with the steelwork, and the fittings and packings of the glands are to be both fire-resisting and watertight (*see also* 405 and 408).

Airtightness of Insulation Lining and Air Ducts

414 Air ducts and insulation linings are to be so constructed and fitted that moving air is prevented from entering the insulation. Special care is necessary where cooling pipes, air refreshing ducts, fan supports, etc., protrude through the lining.

Cargo Battens

415 Cargo battens of about 50 mm.×50 mm. and spaced approximately 0,4 metre apart are to be secured to the vertical surfaces of the chambers clear of air ducts, screens and cooler casings, and are to be fitted to suit the air flow. The outer edges of the battens are to be chamfered.

416 Cargo battens of not less than 75 mm.×75 mm. are to be secured over the tunnel top insulation.

Stiffening of Insulation Linings and Air Ducts

417 Insulation linings and air screens on the sides of chambers are to be suitably stiffened to prevent crushing by cargo, in particular where ship sides are curved inwards and according to the nature of the cargo, whether general or refrigerated, which the Owners intend to carry in the chambers. Air duct sides or insulation linings which may have to support heavy loads are to be constructed to Owners' requirements.

Thermometers

418 Thermometers are to be of approved type, number and position in each chamber.

419 Thermometer tubes with their flanges and covers are to be insulated from the deck plating, and on weather decks they are to be so arranged that water will not run down the tubes when taking the temperatures.

420 The inside diameter of thermometer tubes is to be not less than 50 mm. and the tubes are not to be in contact with cold decks.

421 Where thermometer tubes pass through compartments other than that which they serve, they are to be efficiently insulated.

Galvanizing of Fixtures

422 All steel bolts, nuts, hangers, brackets and fixtures which support or secure cooling appliances, insulation, meat rails, etc., are to be galvanized.

Section 5

TESTS AFTER COMPLETION

Thermometers

501 All thermometers provided for measuring chamber, air suction and air delivery temperatures are to be checked for accuracy by the contractors and a statement handed to the Surveyors. The Surveyors may use their discretion as to whether check tests are necessary.

Air Cooler Fan Outputs and Air Circulating Arrangements

502 Air cooler fans are to be tested by the contractors after the air circulating system has been completed and a statement of the results for each chamber handed to the Surveyors. The statement is to show the static pressure, the cubic feet of air circulated per minute, the fan speed and the power consumption. The air circulation arrangements in the chambers are to be checked for distribution.

Refrigeration Test

503 All plant is to be tested under working conditions and the capabilities of the installation checked by a heat balance test.

Before the commencement of the test the Surveyors are to satisfy themselves that the electrical instruments, gauges and thermometers are accurate.

The chambers are to be cooled down to the temperatures required in the class notation, but not necessarily at the balance period. Unless the decks are insulated so that the steel is exposed to the ambient temperature (*see* D 3107) the chamber temperatures are not to be reduced by more than 1° C. below the notation temperatures except by special arrangement and with the agreement of the Owners and the Builders.

When the chamber balance test temperatures have been reached they are to be maintained constant for a stabilising period during which heat is removed from the insulation, etc., in the chambers, and thereafter the temperatures maintained constant for a balance period of six hours, or longer if found necessary.

To maintain steady balance temperatures compressor speed or power input to the fan motors may be varied, or if necessary compressors may be run on stop-start cycles. Cylinder unloading should be avoided where possible and devices for varying cylinder duty should not be used. All such adjustments and stop-start cycles are to be carefully logged.

504 Observations are to be recorded from the beginning of cooling down to the end of the test. In the early stages logging may be at intervals of about four hours, but external temperatures should be logged hourly for the final eighteen hours of the test, and all other relevant temperatures and pressures, speed and power consumption of compressor and fan motors, power consumption of brine and cooling water pumps logged hourly for the final twelve hours of the test.

505 Where an installation is to be completed and tested during a period when extremely low external temperatures are probable and a reasonable difference between the external and internal temperatures will not be possible without reducing the chamber temperatures below the level referred to in 503, the case is to be submitted for special consideration.

506 In cases where it is reasonable to believe that the refrigerating plant is inefficient an output test on the plant may also be required.

Air Cooler Defrosting Arrangements

507 The air cooler defrosting arrangements are to be tested.

Section 6

SPARE GEAR

601 The following spare gear will be required in all cases :—

1 fan impeller of the propeller type of each size used.

1 set of the wearing parts of the crank shaft seals for each compressor where the crank case is subject to the refrigerant pressure.

1 set of crank shaft coupling bolts of each size used.

1 set of motor coupling bolts and washers, of each size used.

1 compressor piston with piston or connecting rod complete, of each size used.

1 complete assembly of each size of compressor suction and delivery valve.

1 complete set of packing for CO_2 compressor piston rod glands of each size used.

1 set of the working parts, together with packing and piston leathers, for the lubricating oil pump for CO_2 compressor rod glands.

1 gas regulator valve of each size used.

1 float regulator assembly of each size used.

1 set of suction and delivery valves for cooling water, air and brine pumps, of each size used.

1 set of driving belts of each size used.

Sundry lengths and bends of piping together with flanges, couplings and screwing appliances.

Sundry cocks, valves, flanges and fittings.

Assorted bolts, nuts, studs, packing and joint rings.

5 per cent of the total number of electrical or tube thermometers, but not less than two of each.

Not less than two standard thermometers of the necessary temperature range.

1 spare battery for each electric thermometer indicator fitted.

1 hydrometer, where brine is the cooling medium.

1 halide lamp leak detector, where dichlorodifluoromethane or monochlorodifluoromethane is the refrigerant.

2 safety valve springs of each size used.

6 safety discs of each size used.

In cases where approval is given to alternative arrangements under N 104, additional spare gear may be required according to the circumstances of the case.

602 Where steam driven air circulating fans are fitted, the following spare gear will be required :—

For each size used :—

1 crank shaft.

1 steam piston and rod complete.

1 steam cylinder cover.

1 set of connecting rod top and bottom end bearing bushes, and bolts complete.

603 Where the refrigerating machines are direct driven by steam engines or by oil engines, the spare gear is to be in accordance with Chapter K.

604 Where any component of the refrigerating plant is electrically driven the spare gear is to be in accordance with M 2102, and in the case of fan motors, M 2104, except where a duplicate fan motor (*see* N 370) is installed ready for use.

605 It is assumed that the Owners will arrange for the necessary reserve supply of the refrigerant, calcium chloride and oils for the voyage intended.

Section 7

INSTALLATIONS NOT CONSTRUCTED UNDER SURVEY

701 When classification is desired for an installation not constructed under the supervision of the Society's Surveyors, application is to be made to the Committee in writing.

702 Full particulars and plans are to be forwarded for consideration, together with the particulars of the materials of the crankshafts, pressure vessels and pressure piping. The requirements of N 202 are to be used for guidance in regard to the information required.

703 A special examination is to be made at least to the extent required for Subsequent Special Surveys. (*See* N 849 to N 857.)

704 The thickness and material of the insulation, the particulars of the frames, beams, stiffeners and other steel work within the insulation, the air coolers and/or chamber grid piping, the compressors, evaporators and condensers are to be verified, and the particulars of the other components of the refrigerating plant are to be verified so far as practicable.

705 The installation is to conform with the requirements of N 2, N 3, N 4 and N 6, so far as applicable.

706 A test is to be carried out in accordance with N 503 to N 505, and air circulation arrangements in the chambers are to be checked for air distribution.

Section 8

PERIODICAL AND OTHER SURVEYS

Incidence of Surveys

801 For the retention of the class assigned, installations are to be subjected to the periodical surveys specified in the following paragraphs.

Running Survey

802 A Running Survey as detailed in 815 to 829 is to be held at intervals of twelve months, and as detailed in 830 to 837 at the intervals stated therein.

Where desired by the Owners, Running Surveys may be held at shorter intervals of time.

In special circumstances, the Committee will be prepared to consider postponement of a Running Survey for a period not exceeding two months, provided application is made by the Owners prior to the due date of the survey and provided a Loading Port Survey is carried out as near to this date as possible.

Special Survey

803 A Special Survey as detailed in 839 to 857 is to be held at four-yearly intervals, the first four years after the date of the survey for classification and thereafter four years from the date of the previous Special Survey.

A Special Survey will normally become due at the same time as a Running Survey, but when they do not coincide, the date assigned to the Special Survey will be that of the Running Survey.

Where it is convenient for Owners to fulfil the Special Survey requirements at the due date, the Committee will be prepared to consider its postponement, either wholly or in part, for a period not exceeding twelve months from the due date, provided prior application is made by the Owners, and provided the Running Surveys continue to be held at the specified intervals. Any special circumstances which may arise will require to be dealt with as necessary.

Continuous Special Survey of Insulation

804 At the request of Owners, the Committee may agree to the Special Survey requirements of 844 to 846 being carried out on a Continuous Survey basis on ships in which the Continuous Hull Survey system has been accepted. In these cases the insulation in the compartments concerned and the insulation of the refrigerant piping should be exposed or removed as required by the Surveyors, in rotation, with an interval of five years between consecutive examinations of each part.

If the examination during Continuous Surveys reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor.

Survey of Repairs

805 Where any essential repairs and/or renewals are effected to an installation, they are to be carried out under the supervision and to the satisfaction of the Society's Surveyors. Repairs and renewals effected at ports where there is no Surveyor to this Society are to be surveyed by one of the Society's Surveyors at the earliest opportunity.

Alterations and Additions

806 Plans and particulars of any proposed alterations or additions to the refrigerated cargo chambers or the refrigerating plant are to be submitted for approval before the work is put in hand, and the work is to be carried out under the supervision and to the satisfaction of the Society's Surveyors.

Record of Surveys

807 The date following the class notation "Lloyd's RMC" on the certificate indicates the date when the installation was first classed.

The notation "RS with date" indicates the date of the last Running Survey.

The notation "SRMC with date" indicates the date of the last Special Survey.

When the requirements of the Continuous Special Survey and all other requirements of the Special RMC Survey have been completed the notation assigned will be "SRMC (CSI) with date".

The notations when assigned will be recorded in the appropriate section of the Register Book and in the supplements.

Notice of Surveys

808 It is the responsibility of Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Society's Surveyors

It is, however, the normal practice of the Society to give timely notice to Owners when Periodical Surveys of Refrigerated Cargo Installations become due, but the non-receipt of such notice does not absolve Owners from this responsibility.

Loading Port Survey

809 When a Loading Certificate is required by the Owners or their representatives, a survey as detailed in 810 to 814 is to be carried out at the loading port.

In the case of ships engaged on voyages of less than two months duration, a Loading Certificate will be considered as valid for two months, provided the cargoes carried are of such a nature as not to damage the insulation or appliances in the insulated chambers, nor to affect by taint or mould the refrigerated cargoes loaded during that period.

810 The chambers are to be examined in an empty state to ascertain that they are clean and free from odour which may adversely affect the cargo to be loaded, that the brine or other refrigerant pipe grids, cooler coils and connections are free from leakage, that the fixed cargo battens on the vertical surfaces are in good order, that cargo gratings or dunnage battens are provided for the floors or decks as required to suit the class of cargo, and that no damage has been sustained to the insulation or its lining prior to the loading of the refrigerated cargo. Any indications of defective insulation not considered to warrant immediate attention should be noted and specially reported.

811 The Surveyor is to satisfy himself that all scuppers and bilge suctions draining insulated spaces are in good working order, and that the liquid seals are primed.

812 The refrigerating installation is to be examined under working conditions, and the temperatures in the cargo chambers are to be noted.

813 If the ship loads at more than one port, one survey only at the first loading port will be required, provided it includes the examination of all the chambers which are to be used for refrigerated cargo during the voyage and general cargo is not subsequently carried in any of the chambers prior to loading the refrigerated cargo.

814 If there is no Surveyor to the Society available at the loading port(s), or if none is obtainable from a port within a reasonable distance, the Committee will accept the report of a survey held at the loading port by a Surveyor appointed by Lloyd's Agent; or in any case where there is no Lloyd's Agent, the report of a survey held by a reliable Surveyor, if available; if no such Surveyor is available, a report signed by two competent engineers of the ship will be accepted.

General

815 Whenever practicable, the machinery is use is to be examined under working conditions on the ship's arrival at the port of discharge before the refrigerated cargo is unloaded.

Log books or other records should be examined and any breakdowns or indications of deficiency in the installation are to be noted and reported.

Cargo Chambers

816 The cargo chambers are to be examined throughout.

817 Insulation linings and fastenings on the sides, bulkheads and deckheads are to be examined as far as practicable for condition and airtightness. The removal of parts of the linings, or drilling, is not required unless insulation deficiency is known or suspected, but any indication of dampness or leakage into the insulation from tanks, decks, scuppers or other source is to be investigated.

818 The coverings on deck, tank top and tunnel top insulation are to be examined for condition and shrinkage. Where there is evidence of deterioration or dampness the insulation is to be tested by drilling and parts of the covering removed if found necessary.

819 Air ducting and cooler casings, and the fastenings and supports for ducts, grids and meat rails are to be examined as far as practicable for damage or deterioration.

820 Hatch plugs and supports, patent hatch covers and seals, chamber and access doors and frames, bilge and manhole plugs, air refreshing pipes and their closing appliances are to be examined for condition and airtightness.

821 The bilges are to be cleaned and suction pipes, suction roses, sounding pipes and scupper non-return valves examined. The Surveyor should satisfy himself that all scuppers draining the chambers and cooler trays are in good working order.

Air Coolers and Grids

822 Air cooler coils, cooling grids and valves are to be examined. The Surveyor should satisfy himself that sections of the coils or grids are not choked and that the valves are in good working order.

823 Brine refrigerant cooler coils and grids are to be examined whilst under a pressure of $1\frac{1}{2}$ times the working pressure or 3 kg. per cm.^{2} whichever is the greater.

824 Primary refrigerant cooler coils and grids are to be examined whilst under the refrigerant pressure prevailing in the system at the time of the survey, with the plant at rest and the regulating valves opened sufficiently to obtain an approximate balance or pressure throughout the system.

Primary Refrigerant Pressure Vessels and Connections

825 The shells of "shell and tube" and "double pipe" type condensers and evaporators, separators, receivers, driers, filters and other pressure vessels, and the coil terminals of "coil in casing" type condensers and evaporators, are to be examined as far as practicable.

In the case of pressure vessels covered by insulation any evidence of dampness or deterioration of the insulation which could lead to external corrosion of the vessels or their connections is to be investigated.

Piping and Headers

826 Primary refrigerant gas and liquid pipes, brine piping, headers, condenser cooling water piping and valves are to be examined as far as practicable.

Where parts of the piping or headers are covered by insulation an examination of the insulation is to be made as in 825.

Thermometers

827 The thermometers for measuring the chamber, air suction, and air delivery temperatures are to be examined and where repairs or renewals are found necessary the thermometers concerned are afterwards to be checked for accuracy.

Each thermometer is to be tested for accuracy at intervals not exceeding the period between Special Surveys, but not necessarily all at one time. The Surveyor may at his discretion accept the results of thermometer tests carried out by a competent staff or contractor.

NOTE.—In a number of ships, thermometers of a type not approved by the Society have been fitted in addition to those required by N 418: the former need not be examined or tested.

Fans and Fan Motors

828 A general examination is to be made of air cooler fans, their motors, control gear and cables and the insulation resistance measured. The insulation resistance is not to be less than 100000 ohms, and for the purpose of this test each item may be taken separately. The Surveyor may at his discretion accept the results of tests carried out by a competant staff or contractor.

Generating Plant

829 The generating plant supplying electric power to the refrigerating machinery is to be examined generally with a view to ascertaining that the plant is being efficiently maintained.

In the case of ships not classed with the Society, the Surveyor is to ascertain that periodical examinations of the generating plant continue to be held by the Classification Society concerned.

Compressors

830 Reciprocating compressors, including those provided for sub-cooling of the primary refrigerant, are to be opened up in regular rotation so that each compressor is examined within a period of two years. At this survey, cylinders and pistons, valves and seats, crankshafts, connecting rods, piston rods, glands, relief devices, suction filters and lubricating arrangements are to be examined. Crankcase glands and the lower halves of main bearings need not be exposed if the Surveyor is satisfied as to alignment and wear.

831 Alternatively, each compressor may be opened up for examination as described after running for 5000 hours or at intervals of four years, whichever is the lesser period, unless in special circumstances an extension of this period has been agreed by the Committee.

Where this system is adopted, it will be the Owners' responsibility to maintain a record of the running hours of each compressor and to ensure that neither periods of 5000 hours nor four years are exceeded between consecutive examinations of any compressor.

It will be the Surveyor's responsibilty to examine the records at Running Surveys and to report the number of running hours logged by each compressor since it was last examined.

Where other than reciprocating compressors are fitted, or where there is a programme of replacement instead of surveys on board, other survey arrangements may be necessary. Each case will be given individual consideration.

Condensers

832 The water end covers of "shell and tube" and "double pipe" type condensers are to be removed for examination of the tubes, tubeplates and covers, in rotation, approximately half the number of condensers to be examined annually so that all are examined in a period of two years.

Where there are several separate installations in a ship, the number of condensers to be examined annually will be specially considered for each case.

Condenser Cooling Water Pumps

833 The working parts of condenser cooling water pumps, including the standby pump which may be used on other services, are to be examined in regular rotation so that all are examined in a period of two years.

If there are two or more standby sources of cooling water supply the examination may be extended over a period of four years and is to include at least two standby pumps, approximately half the number of pumps to be examined in each two-year period.

Brine and Primary Refrigerant Circulating Pumps

834 The working parts of brine and primary refrigerant pumps are to be examined in rotation so that all are examined in a period of two years.

Prime Movers

835 Where a refrigerating compressor, water, brine or primary refrigerant pump is electrically driven, a general examination is to be made of the motor, control gear and cables and the insulation resistance measured as in 828, at the same time as the compressor or pump is being examined.

Where a compressor or pump is driven by a steam or internal combustion engine, all the working parts of the engine are to be opened up and examined in a similar manner to that specified for compressors in 830, at the same time as the compressor or pump is being examined.

Steam Jet Vacuum Refrigerating Plant

836 Steam jet plant forming the primary refrigerant system is to be examined in rotation at Running Surveys so that all parts, including flash chambers, water spray arrangements, thermo-compressor steam chambers, nozzles, condensers, pumps and ejectors are examined in a period of two years.

Spare Gear

837 The refrigerating plant spare gear is to be checked.

Survey Records

838 A Survey book or other permanent record is to be kept on board the ship to show the date of examination of the various parts. This is to be available to the Surveyor at all times and is to be signed by the Surveyor on the occasion of each survey.

NOTE.—The Surveyor may ask for additional items to be opened up for examination if considered necessary at any survey.

FIRST SPECIAL SURVEY

839 In addition to the requirements for Running Survey as detailed in 815 to 837, the following are to be complied with.

840 Where the refrigerating machinery is driven by internal combustion engines and independent air compressors and air receivers exclusive to the refrigerating plant are installed, the working parts of the compressors and their intercoolers, filters, oil separators and safety devices are to be examined. The air receivers with their mountings, valves and safety devices are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to twice the working pressure.

841 The Surveyor is to satisfy himself that all pressure relief valves and/or safety discs throughout the refrigerating plant are in good order. No attempt, however, should be made to test primary refrigerant pressure relief valves on board ship.

842 In the case of steam jet vacuum refrigerating plants installed for sub-cooling the primary refrigerant liquid, the flash chambers and water spray arrangements, the thermo-compressor steam chambers and nozzles, the condensers, the cooled water circulating, condenser cooling and condensate extraction pumps, and the air pumps or ejectors are to be examined and, if considered necessary, the condensers are to be tested.

843 Sufficient insulation is to be stripped from insulated pressure vessels to permit of the condition of the vessels and their connections being ascertained. Care is to be taken that on replacement of the insulation the vapour sealing of the outer covering is made good.

844 Sufficient insulation is to be stripped from pipes carrying the refrigerating medium at various points of the system, both outside and inside the chambers, to permit of the condition of the pipes being ascertained. Care is to be taken that on replacement of the insulation the vapour sealing of the outer covering is made good.

845 Sufficient air trunking and insulation lining is to be stripped from the chamber overhead and vertical surfaces to permit of the condition of the insulation, insulation linings, grounds, supports, hangers and fixtures which support the insulation, grids, meat rails, etc., being ascertained. Care is to be taken that on replacement the ducts and linings are sealed against air blowing into the insulation.

846 Sufficient tank top insulation is to be stripped to permit of the condition of the grounds and inner insulation lining being ascertained.

847 Sea connections to condenser cooling water pumps are to be opened up and examined.

848 Steam pipes to steam engines driving refrigerating machinery, and to steam jet vacuum refrigerating plants are to be examined as required by C 10 if the temperature of the steam is over 454° C.

In the case of installations on unclassed ships, the Surveyors are to ascertain whether the steam pipes have been similarly dealt with by the Classification Society concerned, and if not, arrangements are to be made for the examination and tests in accordance with C 10.

SUBSEQUENT SPECIAL SURVEYS

849 In addition to the requirements for First Special Survey as detailed in 839 to 848, the following are to be complied with.

850 The coils of gas condensers of the "coil in casing" type are to be examined and tested to a pressure of 17,5 kg. per cm.^{2} for dichlorodifluoromethane systems, 70 kg. per cm.^{2} for ammonia and monochlorodifluoromethane systems, and 140 kg. per cm.^{2} for carbon dioxide systems. Where it is impracticable to remove the coils they may be examined and tested in place.

851 The coils of evaporators (brine coolers) of the "coil in casing" type are to be examined and tested to a pressure of 14 kg. per cm.^{2} for dichlorodifluoromethane systems, 35 kg. per cm.^{2} for ammonia and monochlorodifluoromethane systems, and 105 kg. per cm.^{2} for carbon dioxide systems. Where it is impracticable to remove the coils they may be examined and tested in place.

852 Gas condensers of the "shell and tube" type are to have the water or brine end covers removed and are to be tested to a pressure of 17,5 kg. per cm.^{2} for dichlorodifluoromethane systems, and 28 kg. per cm.^{2} for ammonia and monochlorodifluoromethane systems.

853 Gas evaporators (brine coolers) of the "shell and tube" type are to have the brine end covers removed and are to be tested to a pressure of 14 kg. per cm.^{2} for dichlorodifluoromethane systems and 21 kg. per cm.^{2} for ammonia and monochlorodifluoromethane systems.

854 Primary refrigerant liquid sub-cooling coils in flash chambers of steam jet vacuum refrigerating plants are to be examined and tested to the same pressure as that required for condensers in 850.

855 Where brine or water is used for sub-cooling the primary refrigerant liquid in heat exchangers of the "shell and tube" type, the heat exchangers are to be examined and tested in the same manner as that required for condensers in 852.

"Double pipe" type heat exchangers are to be examined so far as practicable with the gas piping under the same pressures as that required for condensers in 852 and the water or brine from the outlets is to be tested for gas leakage.

Other types of heat exchangers using brine or water are to be examined and tested at the discretion of the Surveyor according to the design of such equipment.

856 Primary refrigerant chamber grids or air cooler coils are to be tested in place to a pressure of 7 kg. per cm.^{2} for dichlorodifluoromethane, 10,5 kg. per cm.^{2} for ammonia and monochlorodifluoromethane systems, and 70 kg. per cm.^{2} for carbon dioxide systems.

857 Steam pipes to steam engines driving refrigerating machinery, and to steam jet vacuum refrigerating plants are to be examined as required by C 10.

In the case of installations on unclassed ships, the Surveyors are to ascertain whether the steam pipes have been similarly dealt with by the Classification Society concerned, and if not, arrangements are to be made for the examination and tests in accordance with C 10.

Section 9

PORTABLE REFRIGERATED CARGO CONTAINERS

General

901 Portable refrigerated cargo containers intended to be carried on the owners' ships, which comply with N 1 to N 8 in so far as they are applicable, except as provided in the following paragraphs, will be included in the installations covered by B 9.

902 The shipowners' name and an identification number are to be clearly marked on each container.

903 Where a container has not been constructed and tested as in the following paragraph 904, it is to be indicated on the container that it is not to be lifted in a loaded condition.

904 Where a container has been constructed for lifting in a loaded condition a deflection test of the structure is to be carried out on the container, or on a prototype, in a loaded condition under the supervision of the Surveyors.

At this test the container is to be lifted with the cargo space loaded with a uniformly distributed load in three successive stages up to 1,25 times the specified maximum cargo load, and the ratio of the deflection to the length of the container is not to be greater than 1 to 1200.

The empty weight of the container and the maximum cargo load are to be clearly indicated on the container.

905 A log book showing the particulars of the refrigeration of the container during each voyage is to be maintained, and this is to be made available to the Surveyor at each of the surveys required by 923.

Where the plant is operated by thermostatic control the intervals during which the machinery is working and at rest should be recorded occasionally, particularly during the period of maximum external temperature conditions of each voyage.

Class Notation

906 The class notation will be in accordance with N 1 except that where the refrigerant condenser is air cooled the class notation shown in N 101 will give the maximum ambient temperature instead of the maximum sea temperature, e.g., "to maintain temp. 10° F. with ambient temp. 104° F. maximum".

Where the refrigerating machinery is electrically driven and dependent on the ship's generators for power, the class assigned will be subject to suitable electric power being available at all times when the container is loaded with refrigerated cargo.

Special Survey during Construction

907 The requirements of N 2 are to be complied with in so far as they are applicable.

Refrigerating Plant

908 The requirements of N 3 are to be complied with in so far as they are applicable, except as modified by the following paragraphs.

909 Where two or more refrigerating units supply refrigeration to a container, or to several containers as a group, the plant is to be capable of efficiently maintaining the minimum internal temperature(s) under the maximum external conditions, to be specified in the class notation, when working 24 hours per day with any one of the refrigerating units out of action.

910 Where one refrigerating unit supplies refrigeration to a container, or to several containers as a group, the unit is to be capable of efficiently maintaining the minimum internal temperature(s) under the maximum external conditions, to be specified in the class notation, when working not more than 12 hours per day if the specified conditions are tropical, or not more than 15 hours per day if the conditions are temperate.

911 Where the refrigerant condenser is air cooled and the maximum gas discharge pressure is above the maxima specified in N 326 and N 337, the design pressure is to be correspondingly increased.

912 Where the design pressure is increased in accordance with 911, the test pressures specified in N 346 are to be increased proportionately.

913 Where "shell and tube" type evaporators (brine coolers) and condensers can be readily removed, the space for the withdrawal and renewal of tubes in accordance with N 355 will not be required.

Cargo Space

914 The external structure, including the door, is to be of robust design and constructed of, or covered with, water vapour-resisting materials, and the joints are to be effectively sealed. The structure is to be carefully examined for tightness before the insulation is applied. The access door is to be airtight when closed.

915 The containers are to comply with the requirements of N 404 and N 405, N 407 and N 408, N 414 and N 415, N 417 and N 422 in so far as they are applicable.

916 Drains of not less than 45 mm. bore are to be provided from the cargo space and air cooler trays, and the drains are to be fitted with means of closure operable from outside the cargo space.

917 Thermometers are to be of approved type and position in the cargo space. Where thermometer tubes are provided the method of attachment is also to be approved.

Tests after Completion

918 The requirements of N 5 are to be complied with in so far as they are applicable.

Spare gear

919 Where two or more refrigerating units supply refrigeration to a container, or to several containers as a group, as in 909, the spare gear to be carried on the ship with the container(s) is to be in accordance with N 6 in so far as that Section is applicable.

920 Where a single refrigerating unit supplies refrigeration to a container, or to several containers as a group, as in 910, a complete spare compressor ready for fitting in place is to be carried on board the ship with the container(s), together with the spare gear required by 919, except those items which are included in the spare compressor.

This will apply up to a total of four containers each with a single identical refrigerating unit on one ship. Where the number exceeds four the additional spare gear required will be specially considered.

921 If at any time a group of containers is divided between two or more ships, spare gear as required by the foregoing paragraphs is to be carried on each ship.

Containers not Constructed under Survey

922 The requirements of N 7 are to be complied with in so far as they are applicable, except as amended by this Section.

Periodical and other Surveys

923 For the retention of the class assigned, periodical and other surveys are to be carried out in accordance with N 8 except as modified in the following paragraphs.

Loading Port Surveys

924 The requirements of N 810 and N 812 are to be complied with and, in addition, the Surveyor is to satisfy

himself that the container is placed on board in such a position as to provide free access to it by the ship's personnel for servicing the refrigerating plant and noting the temperatures; and, where the refrigerant condenser is air cooled, to allow free flow of fresh air to, and heated air from, the condenser.

925 Generating plant supplying power and the cables and connections to the refrigerating machinery are to be examined generally.

926 The Surveyor is also to satisfy himself that the drains from the cargo space and air cooler trays are clear and the closing devices are in order.

927 Where an owner desires a Loading Port Survey of a container which is to be loaded with refrigerated cargo ashore instead of on board the ship, the particular circumstances will require to be specially considered.

28th July, 1966

Running Surveys

928 The requirements of N 815 to N 837 are to be complied with so far as they are applicable. In addition, the cargo space and air cooler drains and their closing appliances are to be examined.

First Special Survey

929 The requirements of N 839 to N 848 are to be complied with so far as they are applicable.

930 Sufficient covering and insulation is to be stripped from the floor of the container to permit of the condition of the insulation, grounds and structure being ascertained.

Subsequent Special Surveys

931 The requirements of N 849 to N 857 are to be complied with so far as they are applicable, and in addition, those of 930.

Chapter P

QUALITY AND TESTING OF MATERIALS

Note:—For list of steel manufacturers see Appendix to this Chapter

Section 1

SHIP, BOILER AND MACHINERY STEEL GENERAL REQUIREMENTS

Approval of Works and Method of Manufacture

101 The steel shall be manufactured at works approved by the Committee, by the open hearth or electric furnace process, or by other process specially approved by the Committee.

Testing and Inspection

102 The prescribed tests and inspection shall be carried out at the place of manufacture before despatch, but in the event of any material proving unsatisfactory during working or fabrication, such material shall be rejected notwithstanding any previous certificates, and the Surveyor may require further tests from other materials from the same batch.

All the test pieces are to be selected and stamped by the Surveyor or an authorised deputy and tested in his presence.

Surface Inspection and Dimensions

103 Surface inspection and verification of dimensions are the responsibility of the steelmaker, and acceptance by the Surveyors of material later found to be defective shall not absolve the steelmaker from this responsibility.

Identification of Materials

104 The steelmaker shall adopt a system for the identification of ingots, slabs and finished pieces which will enable the material to be traced to its original heat, and the Surveyors shall be given full facilities for so tracing the material when required.

Branding

105 Every finished item is to be clearly marked by the makers in at least one place with the Society's brand and the following particulars:—

(i) Agreed identification mark for the grade of steel.
(ii) Name or initials to identify the steelworks.
(iii) Number and/or initials to identify the heat.
(iv) Purchaser's identification mark if required by the purchaser.

Where a number of light materials are securely fastened together in bundles, the manufacturer may, subject to the agreement of the Surveyors, brand only the top piece of each bundle, or alternatively, a firmly fastened durable label containing the brand may be attached to each bundle.

Defacing of Rejected Material

106 In the event of any material, bearing the Society's brand, failing to comply with the test requirements, the brand is to be unmistakably defaced.

Mill Sheets

107 The Surveyor shall be supplied with at least two copies of the mill sheets or shipping statements of all accepted material which documents should be separate for each grade of steel. The documents shall contain, in addition to the description, dimensions, etc., of the material, the following particulars:—

(i) Purchaser's identification marks.
(ii) Identification of the heat.
(iii) Identification of the steelworks.
(iv) Identification of the grade of steel.
(v) Ladle analysis (elements controlled by the specification only).
(vi) Order or ship number for which intended.
(vii) If the ship steel is of rimming quality, this should be stated.

Maker's Certificate

108 Before the mill sheets or shipping statements are signed by the Surveyor, the manufacturer is required to furnish him with a certificate stating the material has been made by an approved process and that it has been subjected to and has withstood satisfactorily the required tests in the presence of the Surveyor or his authorised deputy. The following form of certificate will be accepted if stamped or printed on each mill sheet with the name of the steelworks and initialled for the makers by an authorised official:—

"We hereby certify that the material herein described has been made by the.....process (process to be stated) approved by and in accordance with the Rules of Lloyd's Register of Shipping for Grade.....steel, and is that which has been tested in the presence of the Society's representative with satisfactory results".

Facilities for Inspection

109 The manufacturers shall afford the Surveyors all necessary facilities and access to all relevant parts of the works to enable them to verify that the approved process is adhered to, and for witnessing the selection and testing as required by the Rules, and for verifying the accuracy of the testing equipment.

Steel not Produced where Rolled

110 When steel is not produced at the Works at which it is rolled, a certificate shall be supplied to the Surveyor at the rolling mill stating the process by which it was manufactured, the name of the manufacturer who supplied it, the number of the heat from which it was made and the ladle analysis. The works at which the steel was produced must be approved by the Committee.

Tensile Test

111 The tensile tests shall be carried out by competent personnel in an approved machine of adequate capacity. The machine shall be maintained in a satisfactory and accurate condition and shall be re-calibrated at approximately annual intervals. This calibration is to be carried out by a nationally recognised authority or other organisation of standing and is to be to the satisfaction of the Surveyor. A record of all calibrations shall be kept available in the test house.

The tensile strength is defined as the maximum load divided by the original cross-sectional area of the tensile test piece.

Section 2

STEEL FOR HULL STRUCTURES

NOTE.—*These requirements are primarily intended to apply to steel not exceeding 50 mm. in thickness. For greater thicknesses, certain variations in the requirements may be allowed or required in particular cases after consideration of the technical circumstances involved.*

MILD STEEL

Freedom from Defects

201 (*a*) The minus tolerance in the thickness of plates and sections from those given on the approved plans is not to exceed:—

Nominal thickness "t"		*Tolerance*
	mm.	mm.
Not exceeding	15,0	0,4
Over 15,0 Not exceeding	45,0	(0,02t+0,1)
Over	45,0	1,0

The general standard as laid down by the Rules is to be maintained.

(*b*) The steel is to be reasonably free from segregations, surface flaws and non-metallic inclusions. The finished material is to be free from cracks and lamination. It shall also have a workmanlike finish, and must not have been hammer dressed.

(*c*) Surface defects may be removed by grinding, provided that the thickness is in no place reduced to less than 93 per cent of the nominal thickness but in no case by more than 3 mm. The extent of such repairs shall be agreed in each case with the Surveyors, and the repairs shall be carried out under the Surveyors' supervision unless otherwise agreed.

(*d*) Surface defects which cannot be dealt with as above may be repaired by chipping or grinding followed by welding, subject to the Surveyors' consent and under their supervision, provided:—

(i) that after removal of the defect, and before welding, the thickness of the item is in no place reduced by more than 20 per cent,

(ii) that the welding is carried out by an approved procedure, by competent operators with approved electrodes, and that the welding is ground smooth to the correct nominal thickness,

(iii) that subsequent to the finish grinding, the piece may be required to be normalised or otherwise heat treated at the Surveyors' discretion. Re-normalising will always be required if the piece has been normalised before the repair.

Distinguishing Marks

202 The entire marking (*see* P 105) is to be surrounded by a clear mark in paint of the following distinctive colours:—

Grade A steel	white
Grade B steel	green
Grade C steel	blue
Grade D steel	red
Grade E steel	yellow

Where the name of the steelworks is embossed on finished sections, only the Society's brand and items (i), (iii) and (iv) of P 105 need be surrounded by paint in appropriate colour.

Standard Tensile Test Piece

203 This piece shall have a rectangular cross-section with thickness equal to that of the material from which it is cut and a width of 25 mm. with a length between gauge marks of 200 mm. The parallel length shall not be less than 230 mm. The ends of the test piece may be increased in width to suit the grips of the machine, the transition between the different widths being made with a gentle curve.

The test pieces are to be cut with their lengths transverse to the principal direction of rolling except in the case of sections and narrow flats.

Alternative Tensile Test Pieces

204 Tensile test pieces of other dimensions or of cylindrical form may be used, provided that the elongations comply with 205, and provided that the cross-sectional area is not less than 161 square mm.

Elongations in Tensile Test

205 (*a*) The required minimum elongations, E, are indicated in the appropriate Rules for each grade of steel. (For ship steel *see* Table II.) These elongations are based on test pieces having gauge lengths equal to 5,65 times the square root of the cross-sectional area, or 5 times the diameter.

(*b*) For test pieces having gauge lengths bearing other relationships to the cross-sectional area, the equivalent elongations shall be calculated from the following formula:—

$$n = 2E\left(\frac{\sqrt{A}}{L}\right)^{0,40}$$

where n is the equivalent minimum elongation,

A is the actual cross-sectional area of the test piece,

L is the actual gauge length,

E is the specified minimum percentage elongation for test pieces in which

$L = 5,65\sqrt{A}$ (*see* 205 (*a*)).

NOTE.—A *and* L *may be in any consistent units.*

(*c*) For the "standard" test piece (*see* 203) the minimum percentage elongations shall not be less than the following:—

Thickness	*Minimum Elongation*
6 mm.	0,68E
30 mm. and over	0,95E

where E is the specified minimum as per 205 (*a*) above. The elongations for thicknesses between 6 mm. and 30 mm. may be obtained from the above by linear interpolation.

Bend Tests

206 The bend test shall consist in bending a strip or bar of the material until the ends are parallel to each other, and at a distance apart not exceeding three times the thickness or diameter of the strip or bar.

The strips shall have a width at least equal to the thickness but not less than 25 mm. and a thickness not less than that of the material tested, retaining the original rolled surfaces. The sharp edges of the strip may be removed by filing or machining, to a radius not exceeding $\frac{1}{10}$ of the thickness of the strip.

When the power of the available testing machine is insufficient to bend a test piece of the full thickness, this latter may be reduced by machining from one face or by turning down a round bar provided that the final thickness or diameter is not less than 25 mm. Strips shall be so bent that the original rolled surface is on the tension side.

The strips shall be cut with their lengths transverse to the principal direction of rolling except in the case of sections and narrow flats. The bending may be performed by pressure or by blows.

The bend test will be considered successful if no cracks or laminations appear.

Impact Tests

207 The impact test pieces (where specified) shall be of the Charpy V-notch type, 10 mm. square in cross-section, 55 mm. long, and having in the centre of the length of one face a perpendicular V-notch with an included angle of 45°, a depth of 2 mm. and a root radius of 0,25 mm. The specimens are to be accurately machined to the tolerances given in Table 1 and to a good finish. The prescribed dimensions are to be carefully and systematically checked. The test pieces shall be cut with their longitudinal axes parallel to the final direction of rolling of the material. The notch shall be cut in a face of the test piece which was originally perpendicular to the rolled surface.

TABLE I

DIMENSIONS AND TOLERANCES FOR CHARPY V-NOTCH TEST PIECES

Dimensions	Nominal Dimension	Tolerance
Length	55 mm.	±0,60 mm.
Width	10 mm.	±0,11 mm.
Thickness	10 mm.	±0,11 mm.
Angle of notch	45°	±2°
Depth below notch ...	8 mm.	±0,11 mm.
Root radius	0,25mm.	±0,025 mm.
Distance of notch from end of test piece	27,5 mm.	±0,42 mm.
Angle between plane of symmetry of notch and longitudinal axis of test piece	90°	±2°

The position of the notch shall not be nearer than 25 mm. to a flame-cut or sheared edge.

In the case of sections, the test pieces are to be cut from the thickest part.

The tests are to be carried out with the test pieces at a temperature carefully controlled to within $\pm 1°$ C. of the required temperature, on a Charpy impact machine of approved type installed in an approved manner having a gap of 40 mm., a striking velocity between 4,5 and 6 metres per second, and a striking energy of not less than 15 kilogramme metres. The angle of the striking edge of the pendulum is to be 30° with the edge rounded to a radius not exceeding 2 mm. The machine is to be periodically checked and calibrated on the lines indicated in P 111.

Alternative Types of Test

208 Other alternative types of test may be substituted for the Charpy V-notch impact test provided that equivalent standards of notch ductility can be established to the satisfaction of the Society.

Number of Tensile Tests

209 For each batch presented, one tensile test shall be made from one piece rolled from each cast unless the weight of finished material is greater than 40000 kgs. in which case one extra test shall be made from each 40000 kgs. or fraction thereof. Additional tests are to be made for every variation of 5 mm. in the thicknesses of pieces from the same cast.

Number of Bend Tests

210 One bend test is to be made from each piece rolled, except that one bend test only need be made from every two pieces having a finished weight of less than 2000 kgs. each, provided they are from the same cast.

Number of Impact Tests (where required)

211 Unless otherwise specified for a particular grade of steel, at least one piece is to be selected for impact testing from the thickest batch from each cast, unless the weight of finished material rolled from the cast is greater than 40000 kgs. in which case one extra test will be made from a different piece from each 40000 kgs. or fraction thereof, provided that the same procedures have been used in manufacture.

When plates of different widths are included in batches of the same thickness the widest plate is to be preferred for testing.

From each piece so selected, three impact tests as described in 207 shall be carried out. The average values obtained from these tests shall comply with the requirements. If, however, the average obtained fails to comply by an amount not exceeding 15 per cent of the required value, three additional test pieces from the same sample may be tested, and the results added to those previously obtained to form a new average, which must comply with the requirements.

Definitions

212 The term "piece" is to be understood to mean the rolled product from a single slab or from a single ingot if this is rolled directly into plates, bars or sections. The term "item" means any single plate, bar or section as delivered. The term "test piece" where it occurs means the sample of material which is actually tested.

Additional Tests before Rejection

213 (*a*) When the tensile or bend tests on the first piece selected in accordance with 209 and 210 fail to meet the requirements, two further tests of the same kind may be made from the same piece. If both these additional tests are satisfactory the piece and the remaining pieces from the same cast may be accepted.

(*b*) If the additional tests referred to in (*a*) are unsatisfactory the piece is to be rejected, but the remaining material from the same cast may be accepted provided that two of the remaining pieces selected in the same way are tested with satisfactory results.

(*c*) If the impact tests, carried out in accordance with 211 on the first piece selected, fail to meet the requirements the piece is to be rejected, but the remaining material from the same cast may be accepted provided that two of the remaining pieces, selected in the same way, are tested in the same way with satisfactory results.

(*d*) If any test piece fails because of faulty preparation or (in the case of a tensile test) because of fracturing outside the middle half of the gauge length, the defective test piece may at the Surveyor's discretion be discarded and replaced by an additional test piece from the same piece.

(*e*) At the option of the steelmakers, rejected material may be re-submitted after heat treatment or re-heat treatment or may be re-submitted as another grade of steel, and may then be accepted provided that the required tests are satisfactory.

Position of Samples for Testing

214 Except where otherwise specially agreed, the samples taken from the rolled material for the preparation of test pieces are to be cut from the end of the piece corresponding to the top end of the ingot. When the axis of the ingot is transverse to the length of the piece, either end may be selected but the sample should preferably be taken near to the edge corresponding to the top of the ingot.

TABLE II

GRADE	A	B	C	D	E
1. METHOD OF MANUFACTURE	As P 101	As P 101	Process to be specially approved	Process to be specially approved	Process to be specially approved
2. DEOXIDATION	Any method. (For rimmed steel see Note 1)	Any method except rimmed steel	Fully killed, fine grain practice (Aluminium treated)	Any method except rimmed steel	Fully killed, fine grain practice (Aluminium treated)
3. AUSTENITIC GRAIN SIZE (McQuaid-Ehn method ASTM scale (*See* P 217)	—	—	5 or finer To be determined on each charge (*see* Note 4)	—	5 or finer To be determined on each charge
4. CHEMICAL COMPOSITION (ladle analysis)					
Carbon	*See* Note 2	0,21% max.	0,23% max. } Note	0,21% max. } Note	0,18% max. } Note
Manganese ...	*See* Note 2	0,80% min. } *See* Notes 3 & 5	0,60% to 1,40% } 5	0,60% to 1,40% } 5	0,70% to 1,50% } 5
Silicon	—	—	0,15% to 0,30%	0,35% max.	0,10% to 0,35%
Sulphur	0,05% max.	0,05% max.	0,05% max.	0,05% max.	0,05% max.
Phosphorus ...	0,05% max.	0,05% max.	0,05% max.	0,05% max.	0,05% max.
5. TENSILE TEST					
Tensile strength, kg./mm.² ... (*See* P 111)	41 to 50	41 to 50	41 to 50	41 to 50	41 to 50
Elongation E.% on $L=5{,}65\sqrt{A}$ ... (*See* P 205)	22%	22%	22%	22%	22%
6. IMPACT TEST					
Temperature ...	—	—	—	0° C.	—10° C.
Energy	—	—	—	35 ft. lb. min. or 4,84 kg.m. min.	45 ft. lb. min. or 6,22 kg.m. min. Every plate to be tested
7. BEND TEST	As P 206	As P 206	As P 206	As P 206	As P 206
8. HEAT TREATMENT	*See* P 215	*See* P 215	Normalised over 33 mm. thick	*See* P 215	Normalised

NOTES.—TABLE II

1. For Grade A, rimming steel may be accepted up to 12,5 mm. thick inclusive, provided that it is stated on the mill sheets to be rimming steel and is not excluded by the purchaser's order.

2. For Grade A in thicknesses over 12,5 mm. the manganese content shall not be less than 2,5 times the carbon content.

3. For Grade B, when the silicon content is 0,15 per cent or more (killed steel) the minimum manganese content may be reduced to 0,60 per cent.

4. For Grade C the determination of grain size may be alternatively substituted by impact tests as required for Grade D.

5. For Grades B, C, D and E, the sum of carbon content plus $\frac{1}{6}$ of the manganese content shall not exceed 0,40 per cent.

6. For use of Grade C in lieu of Grade D (*see* D 103).

Heat Treatment

215 Unless otherwise specified, or required by the conditions of approval of the process, the material may be presented in the "as rolled" or heat treated condition at the maker's option, subject to full compliance with the remainder of these Rules, and provided that the material which is presented in the normalised or otherwise heat treated condition is to be tested separately from material presented in the "as rolled" condition, even when all such material is from the same cast.

The sample of material from which test pieces are cut must be heat treated together with and in the same way as the material presented. Test specimens may not be separately heat treated in any way.

Chemical Analysis

216 The chemical composition shall be determined by the makers in an adequately equipped and competently staffed laboratory on samples taken from each ladle of each cast. The maker's analysis will be accepted subject to occasional checks if required by the Surveyors.

Austenitic Grain Size

217 The austenitic grain size where required is to be determined by the McQuaid-Ehn method from samples representative of each ladle of each cast. The grain size numbers indicated refer to the ASTM scale described in ASTM E112–58T, or any later ASTM specification which may supersede it.

Applications

218 For information regarding requirements for the application of the different grades of steel, reference should be made to the following paragraphs:—

D 103, D 3104, D 3105, D 3106, D 3711, D 3712, D 4010, D 4011, Sections D 70, D 71 and D 72.

HIGHER TENSILE STEEL

The following paragraphs do not constitute a complete specification for higher tensile steel for hull construction but are intended for the guidance of Steelmakers and Shipbuilders.

General

219 The requirements of P 1 and P 2 are to be complied with so far as they are applicable and as amended in the following paragraphs.

Approval of Steel

220 Full details of the method of manufacture including chemical composition, heat treatment and mechanical properties are to be submitted for approval. If considered necessary, tests are to be made on samples of steel manufactured in accordance with the proposed specification.

The steel should be capable of being fabricated and welded under shipyard conditions. Low hydrogen electrodes should be used unless other electrodes have been approved for the particular steel concerned. Preheating may be necessary depending on the chemical composition of the steel, the ambient temperature, the amount of restraint in the structure, and the size of electrode to be used.

Number of Tests

221 At least one tensile test, one bend test and one set of three Charpy V-notch tests are to be made on each piece (*see* 212) presented for acceptance. (These requirements may be reconsidered after the intial stages of production.)

Mechanical Properties

222 (*a*) The tensile strength is to be within the limits given in the approved specification. The specified range between maximum and minimum is not to exceed 12,6 kg. per mm.^{2}.

(*b*) The upper yield stress or 0,5% proof stress is to be within the limits given in the approved specification and, in any particular test, is not to exceed 80% of the actual tensile strength. (*See also* 223 and 224.)

(*c*) The elongation in the tensile test shall be in accordance with the approved specification.

(*d*) Bend tests. The test pieces are to be bent cold without fracture. The diameter of the former and the angle of bend are to comply with the approved specification.

(*e*) The Charpy V-notch impact values are to be determined in accordance with 207 and 211. The percentage crystallinity, based on the original area, is to be recorded for information.

GRADE	TEST TEMP.	MINIMUM ENERGY kg. m.
AH (For Grade A application)	0°C.	2,765 (*see* Note)
DH (For Grade D application)	0°C.	$4{,}84 \times \frac{1}{\sqrt{k}}$
EH (For Grade E application)	−10°C.	$6{,}22 \times \frac{1}{\sqrt{k}}$

$$\text{where } k = \frac{70,9}{Y + U}$$

and Y = specified minimum upper yield stress or 0,5% proof stress in kg. per mm.^{2} or 0,7 U whichever is the less.

U = specified minimum tensile strength plus one half of the specified range, in kg. per mm.^{2}

NOTE.—The necessity for impact testing of Grade AH plates will depend on the particular method of manufacture and will be decided when the specification is submitted for approval.

Determination of Upper Yield Stress

223 This is considered as the stress at which, under moderately fast rates of loading, a sudden increase occurs in the gauge length and may be observed either by:—

(1) measurement with dividers

(2) a distinct drop in the testing machine lever

(3) a marked hesitation or fall back in the movement of the pointer of the indicating machine.

In cases of doubt the upper yield stress shall be determined by means of dividers or an extensometer, and shall be taken as the stress corresponding to an increase of at least 0,5% of the original gauge length.

For materials which do not show a well defined yield point the 0,5% proof stress should be determined.

Determination of 0,5% Proof Stress

224 The 0,5% proof stress shall be determined from a stress strain diagram on which a line is drawn parallel to the straight portion and distant from it by an amount representing an increase in strain of 0,5%. The point at which the line cuts the curve represents the 0,5% proof stress.

Surface Inspection

225 Attention is drawn to P 103 and it is recommended that both surfaces of all plates be carefully inspected at the steelworks and the edges examined for laminations or other defects.

Freedom from Defects

226 If surface defects are repaired by welding (*see* 201 (*c*)) the procedure shall be appropriate to the steel and a suitable heat treatment will be required.

Marking

227 Distinguishing marks are to be as required by P 105 and 202 but the grade mark is to be followed by a letter "H" (as in 222 (*e*)). A large letter "H" is also to be painted near the brand marking in the appropriate colour given in 202.

Section 3

STEEL FOR BOILERS, PRESSURE VESSELS AND WELDED MACHINERY STRUCTURES

General

301 Plates, sections and bars intended for marine boilers, pressure vessels and welded machinery structures are to comply with the requirements and tests of this section. The requirements are not applicable to pressure vessels containing radio-active materials or gases.

Orders for Materials

302 The order should specify the required type, grade and condition of the material, and the purpose for which it is intended.

Process of Manufacture

303 The steel is to be made at an Approved Works by the open hearth, electric furnace or other approved process. The melting shop practice is to be such as to minimise the included non-metallic contents of the steels. Ingots are to be cast in chilled moulds.

Carbon and carbon-manganese steels are to be killed or semi-killed. Rimmed steels are not acceptable.

Sufficient discard is to be made from the top and bottom of each ingot to ensure soundness in the portion used for plates, bars and sections. Periodically and at the Surveyor's discretion sulphur prints or other suitable proving tests may be required from the rolled material to demonstrate that this has been fulfilled.

The size of ingot is to be proportioned to the thickness of the plate, section or bar in order that the amount of rolling work is adequate to ensure a satisfactory steel structure in the finished product.

Freedom from Defects

304 The steel is to be free from harmful segregations, flaws and laminations. It is to have a workmanlike finish and must not have been hammer dressed. Material despatched from the steel works must not have been repaired by welding.

Slight scale or shell may be removed by careful chipping, filing, grinding, or sand- or shot-blasting. Such rectification must be completed to the satisfaction of the Surveyor.

STEEL PLATES

Carbon and Carbon-Manganese Steel Plates

305 Provision is made for carbon and carbon-manganese steel plates of thicknesses up to 150 mm. and having tensile strengths ranging from 38 to 60 kg. per mm.^{2} For purposes of constructional applications and test requirements the steels are graded according to tensile strength as listed in Table I.

TABLE I

MECHANICAL PROPERTIES OF PLATES, SECTIONS AND BARS

Material—Carbon and Carbon-Manganese Steels

Grade	Tensile Strength kg. per mm.^{2}		Minimum Percentage Elongation on Gauge Length			Bend Test Max. Radius of Former
	Min.	Max.	200 mm.	$4\sqrt{A}$	$5{,}65\sqrt{A}$	
1	38	44	25*	30	26	1 t
2	41	47†	23*	29	25	1 t
3	44	50†	20*	27	23	$1\frac{1}{2}$t
4	47	54†	18*	24	21	$1\frac{1}{2}$t
5	50	60	17*	22	19	$1\frac{3}{4}$t

* For plates under 9,5 mm. in thickness the minimum percentage elongation values may be reduced by 3.

† For individual plates exceeding 10000 kg. in weight the maximum tensile strength may be increased by 3,2 kg. per mm.^{2}

A is the area of the cross-section of the test piece.

t is the thickness or diameter of the test piece.

NOTE.—When these steels are used for welded constructions, attention should be given to J 2203 and J 2214. These requirements are particularly important for Grades 4 and 5 steels.

Chemical Composition of Carbon Steels

306 (*a*) Ladle analyses of carbon steels are to comply with the following ranges of chemical composition:—

Carbon 0,23% max. * for Steels of Grades 1 and 2
0,26% ,, † ,, ,, ,, Grade 3
0,30% ,, ‡ ,, ,, ,, Grades 4 and 5

Silicon 0,15% to 0,35% (applicable to killed steels only)

Manganese 0,50% to 1,00%

Sulphur 0,050% max.

Phosphorus 0,050% max.

* For plates over 75 mm. thick the carbon content may be increased to 0,25% max.

† For plates over 75 mm. thick the carbon content may be increased to 0,28% max.

‡ For plates over 75 mm. thick the carbon content may be increased to 0,32% max.

Residual elements are to be maintained as low as possible and should not exceed the following:—

Copper 0,30%
Nickel 0,30%
Chromium 0,25%
Molybdenum ... 0,10%
Total Residuals ... 0,70%

Chemical Composition of Carbon-Manganese Steels

(*b*) Ladle analyses of carbon-manganese steels are to comply with the following range of composition:—

Carbon ... ... 0,20% max.
Manganese ... 1,60% max.
Silicon ... ... 0,15% to 0,50% (for killed steels only)
Sulphur ... ... 0,050% max.
Phosphorus ... 0,050% max.

The residual elements are to comply with the limitations given in 306(a) for the composition of carbon steels.

In addition to the above, for carbon-manganese steels the sum of the carbon percentage and one sixth of the manganese percentage is not to exceed:—

0,40 for Steels of Grades 1 and 2
0,42 for Steels of Grade 3
0,44 for Steels of Grades 4 and 5

Low Alloy Steel Plates

(*c*) Where it is proposed to use low alloy steels, particulars of the manufacture, chemical composition, mechanical properties and heat treatment are to be submitted for approval. For high temperature applications typical long-term creep and rupture data, scaling and corrosion resistance at the operating temperatures are to be submitted if required. These steels will be tested and accepted on the basis of the approved specification and such other tests as may be considered necessary.

Statement of Analysis

(*d*) The steelmaker is to provide a statement giving the ladle analysis of the steel for each plate. For a carbon or a carbon-manganese steel this should include the carbon, manganese, silicon, sulphur and phosphorus contents. For low alloy steels the analysis should also include the principal alloying elements.

Residual elements need not be stated in all cases but these may be required for periodical check by the Surveyor in attendance at the steelworks.

Steels for Boilers and other Pressure Vessels

307 The grades of carbon and carbon-manganese steel plates are restricted to the applications in boiler and pressure vessel construction as listed in Table II.

Killed steel is to be used for Class 1 fusion welded and Class 1 forged welded pressure vessels.

Silicon killed steel is to be used for pressure vessels where the operating metal temperatures exceed 400° C.

TABLE II

Application	Grade of Steel
Welded Pressure Vessels Class 1 ...	1 2 3 4 5
,, ,, ,, ,, 2A, 2B and 3	1 2 3
Shells of all-riveted boilers	2 3 4
Shells of riveted boilers with welded compensating rings and attachments	2 3
Boiler furnaces, combustion chambers and flanged plates	2
Forge welded pressure vessels ...	1 2

Steel intended for pressure vessels operating at low metal temperatures should be fine grained and may be aluminium killed; proposed applications are to be submitted for approval.

Steels for Welded Engine Structures

308 Grades 1 and 2 carbon and carbon-manganese semi-killed steels are suitable for welded engine bedplates and similar engine structures and are acceptable as meeting the requirements of H 903.

Heat Treatment of Plates

309 Grades 1, 2 and 3 carbon and carbon-manganese steel plates exceeding 44 mm. thickness and all thicknesses of Grades 4 and 5 plates are to be normalised. The steelmaker is to provide a statement giving the heat treatment condition of each plate.

Hot Spun, Bent or Pressed Plates

310 When plates are hot formed in the production of cylindrical shells and dished ends for boilers and other pressure vessels, the fabricator must either demonstrate that the process is so controlled as to ensure that the finished steel has a normalised structure or normalise the parts on completion of the operation.

For low alloy steels and Grades 4 and 5 carbon and carbon-manganese steels check tensile tests are required from each hot formed (and where applicable heat treated) cylindrical shell and dished end. Test pieces are to be selected from material which is to be discarded from the hot formed part. Providing the Surveyor's consent is obtained, a curved test plate may be cold flattened to obtain a suitable test piece.

Alternative procedures to the above may be submitted for special consideration.

Number of Tests—Plates

311 At least one set of mechanical tests comprising a tensile and a bend test is to be made on the material of each plate as rolled. One set of test pieces is to be selected from the material at the quarter-width of each plate weighing less than 2500 kg. For each heavier plate, one set of test pieces is required from the quarter-width of both ends, except where the material will be used for the fabrication of welded engine structures, when only one set of tests is required. The test pieces are to be cut transverse to the principal direction of rolling.

Where plates are normalised at the steelworks the test material is not to be removed from a plate until the heat treatment is completed.

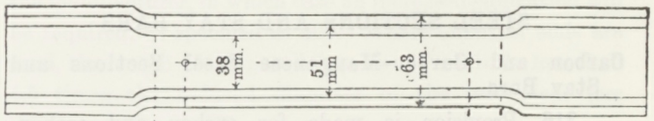
If specified by a manufacturer of fusion welded boilers or pressure vessels, test material cut from plates may be stress relief heat treated before machining the test pieces. This heat treatment is to be in accordance with J 1925.

NOTE.—Although this procedure may provide for some loss of tensile strength of the plates due to stress relief heat treatment, final acceptance is based on the actual tensile strength of the cross weld tensile test piece detailed in J 1920.

Tensile Test Pieces for Plates

312 Wherever practicable the rolled surfaces are to be retained on two opposite sides of the test piece. When the elongation is measured on a standard test piece having a gauge length of 200 mm., for material more than 22 mm. in thickness the width of the test piece between the gauge points is not to exceed 38 mm.; for material 22 mm. to 9,5 mm. in thickness, inclusive, the width is not to exceed 51 mm.; for material less than 9,5 mm. in thickness the width is not to exceed 63 mm. In other respects the test pieces are to conform generally to the standard test piece A.

TEST PIECE A



For Thicknesses over 22 mm.:— Maximum width allowed = 38 mm.

For Thicknesses 9,5 mm. to 22 mm.:— Maximum width allowed = 51 mm.

For Thicknesses under 9,5 mm.:— Maximum width allowed = 63 mm.

Any straightening of the test pieces which may be required is to be done cold. For plates over 38 mm. in thickness a round proportional tensile test piece may be used as an alternative provided the cross-sectional area is not less than 3,2 cm.^{2} (See also 305, Table I).

For check tensile tests on parts hot formed from plates, any suitable standard test piece is acceptable providing the cross-sectional area is not less than 1,6 cm.^{2}

Bend Test Pieces for Plates

313 Bend test pieces if practicable are to be full plate thickness and not less than 38 mm. in width. For thick plates two bend test pieces, 38 mm. wide by 25 mm. thick can be used as an alternative, providing the tension surfaces of the two pieces are parts of the original surfaces of the plate. Bend test pieces may be prepared by shearing or machining and the rough edges may be removed with a file before testing.

Mechanical Properties—Plates

314 The tensile properties determined on each test and check test piece are to comply with the requirements of Table I for the particular grade of steel.

Each bend test piece is to withstand cold bending through 180° without fracture over a former with a maximum radius as given in Table I for the grade of steel.

Additional Tests before Rejection

315 Where either the tensile test or bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the plate, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the plate is to be judged by the results of the duplicate test or tests and not by the original test or tests which failed. If any one of the retests fails the plate is unacceptable.

However, at the discretion of the Surveyor and if requested by the maker, the plate may be heat treated and offered for further testing. In this connection the results of the previous tests are to be disregarded.

STEEL SECTIONS AND STAY BARS

Carbon and Carbon-Manganese Steel Sections and Stay Bars

316 Provision is made for carbon and carbon-manganese steel sections and stay bars having tensile strengths ranging from 41 to 50 kg. per mm^2. These are graded on mechanical properties as follows:—

Bar or Section	*Grade in Table I*
Angles, Tees and other Sections	2 and 3
Longitudinal Stay Bars	2 and 3
Combustion Chamber Stay Bars	2

Where any of these sections or bars is to be welded to the pressure parts of a boiler or pressure vessel the composition of the grade of steel is to comply with the requirements of 306(a) or 306(b).

Other Grades or Types of Steel

317 Where it is proposed to use either a steel of a grade other than those permitted in 316 or a low alloy steel, particulars of the chemical composition, mechanical properties and heat treatment are to be submitted for approval.

Number of Tests—Sections and Bars

318 For each size of section or bar rolled from the same charge the numbers of tensile test pieces required are as undernoted:—

Sections and Bars over 44 mm. diameter	8 or less	1 tensile test
	9 to 29	2 tensile tests
	30 or over	1 tensile test for 15 or part of 15
Bars 44 mm. diameter and under	20 or less	1 tensile test
	21 to 99	2 tensile tests
	100 or over	1 tensile test per 50 or part of 50

A bend test piece is to be taken from each section as rolled. For each tensile test required from bar material, a bend test is also to be made.

Tensile and Bend Test Pieces for Sections and Bars

319 For sections the tensile test pieces are to be prepared in accordance with the requirements of 312 and 313. For bars, tensile test pieces may be either the full section as rolled or may be machined to a convenient size, provided the area of the reduced portion is not less than 3,2 cm^2. Any of the gauge lengths given in Table I may be used.

Bend tests from sections are to be prepared and tested in accordance with the requirements for plate material. Bars may be tested on either the full section as rolled or on a section reduced by machining to a diameter of not less than 25 mm.

Mechanical Properties—Sections and Bars

320 The tensile properties determined on each test piece are to comply with the requirements of Table I for the particular grade of steel or approved specification.

Each bend test piece is to withstand cold bending through an angle of 180° without fracture over a former with a maximum radius as given in Table I for the grade of steel or as otherwise approved.

Additional Tests before Rejection

321 Where either the tensile or bend test, or both, fail, and the Surveyor considers the fractured test pieces or the results obtained therefrom do not fairly represent the quality of the section(s) or bar(s), duplicates of the test or tests which failed are to be made if requested by the maker. For a single section or bar the pieces for retest are to be cut adjacent to the original test material. For batches, one of the pieces for retest is to be taken from that position and the other from a different section or bar in the batch.

If any one retest fails the sections or bars are unacceptable but at the discretion of the Surveyor and on request of the maker either each item in a batch may be tested separately or the items may be heat treated and offered for further testing.

Seamless Receivers

322 In the case of seamless receivers, the rules for material will be the same as for boiler shells, but the permissible extension may be 2 per cent less than that required for boiler plates.

The thicknesses of seamless receivers are to be verified by the Surveyor before the ends are closed in, and at this time the Surveyor is to select and mark the test pieces required from either of the open ends of the tube.

The test pieces are to be subjected to the same heat treatment as that given to the receivers.

Section 4

RIVET BARS AND MANUFACTURED RIVETS

Testing of Material

401 All material from which rivets are manufactured is to be tested.

Rivets are not to be manufactured from steel or ingot iron bars in which the sulphur segregates and other non-metallic substances are concentrated in the core. To ensure this, a sulphur print is to be taken from the material of each charge, and where the weight of bars as rolled from one charge exceeds 10000 kg., additional sulphur prints may be taken.

Number of Tests

402 In the case of steel bars, one tensile test piece is to be taken from each charge used for rivet bars; but where the weight of bars as rolled from one charge exceeds 10000 kg., an additional tensile test is to be made from each further 10000 kg. or portion thereof.

403 In the case of wrought iron bars, two tensile tests shall be taken from every 3000 kg. or portion thereof in each batch of any order presented for inspection, except that, in the case of lots of 1000 kg. or less, one tensile test shall be accepted.

404 In the case of ingot iron bars, one tensile test piece is to be taken from each charge used for rivet bars; but where the weight of bars as rolled from one charge exceeds 10000 kg., an additional tensile test is to be made from each further 10000 kg. or portion thereof.

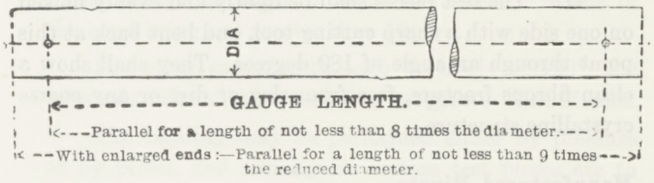
405 For rivet bars of steel or ingot iron one dump test is to be made for each tensile test.

Tensile Test Pieces

406 Bars may be tested full size as rolled, or they may be turned down to a convenient size, and if tested 25 mm. in diameter, or under, the test piece is to have a gauge length of eight times the diameter. Where enlarged ends are used, the length of the parallel portion is not to be less than nine times the reduced diameter of the test piece (*see* standard test piece B).

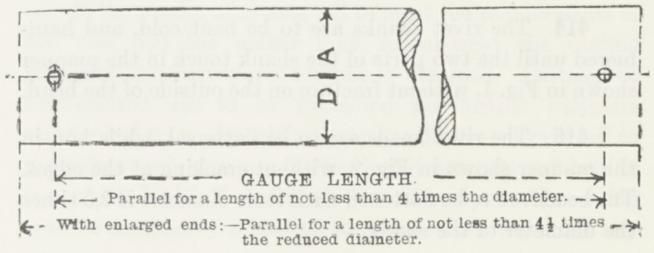
The sectional area of the test piece is not to be less than 160 mm^2.

TEST PIECE B



407 Where bars are above 25 mm. diameter, and are tested full size as rolled, or have been turned down and the resulting test piece is above 25 mm. diameter, a gauge length of four times the diameter may be used if preferred by the manufacturer, in which case an increased elongation will be required, as specified in 409. Where enlarged ends are used, the length of the parallel portion is not to be less than 4,5 times the reduced diameter of the test piece (*see* standard test piece C).

TEST PIECE C



Straightening of Test Pieces

408 Any straightening of test pieces which may be required is to be done cold.

Tensile Tests

409 The tensile strengths and elongations of rivet bars are to be within the following limits:—

Material	Tensile Strength Kg. per mm².	Minimum Elongation	
		Gauge Length	
		4 × d (Test piece C)	8 × d (Test piece B)
Steel	41—47	30%	25%
Wrought Iron	33—39	—	22%
Ingot Iron	33—39	30%	25%

Dump Test

410 Short lengths, equal to twice their diameter, cut from the rivet bars shall, when cold, withstand without fracture being compressed to half their length.

Nicked Bend Tests

411 In the case of wrought iron bars one nicked bend test shall be taken from each 3000 kg. of material or portion thereof in each batch of any order presented for inspection.

412 The test pieces shall be lightly and evenly nicked on one side with a sharp cutting tool, and bent back at this point through an angle of 180 degrees. They shall show a clean fibrous fracture, free from slag or dirt or any coarse crystalline structure.

Manufactured Rivets

413 Rivets selected by the Surveyor from the bulk are to withstand the tests described in 414 to 416.

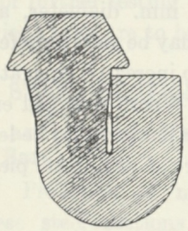


FIG. 1

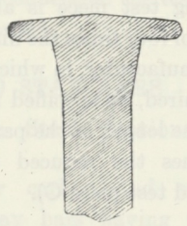


FIG. 2

414 The rivet shanks are to be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

415 The rivet heads are to be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The heads are to be flattened until their diameter is 2,5 times the diameter of the shank.

416 In the case of steel or ingot iron rivets, samples are to be selected by the Surveyor for examination by means of sulphur prints, to ensure that the material is free from marked central segregation.

Section 5

STEEL CASTINGS

Process of Manufacture

501 Steel for castings is to be made by the acid open hearth, basic open hearth or electric furnace process or by such other process as may be approved by the Committee and is to contain not more than 0,05 per cent sulphur or 0,05 per cent phosphorus.

CARBON AND CARBON MANGANESE STEEL CASTINGS

Heat Treatment

502 Castings are to be heat treated in properly constructed furnaces which are efficiently maintained and have adequate temperature control.

Castings are to be heated to a uniform temperature above the upper critical point to refine the grain and are to be:—

(a) fully annealed by cooling slowly in the furnace in a uniform manner,
or

(b) normalised by cooling in air followed, where appropriate, by a tempering treatment at a minimum temperature of 630° C.,
or

(c) a combination of both of these treatments, e.g. annealing or homogenising at a relatively high temperature as a preliminary refining treatment to subsequent normalising and tempering.

After rough machining, crank webs, combined web and pin castings and other castings intended for important engine components, which in service are subject to dynamic loading, are to be stress relieved within the temperature range of 630/650° C., followed by furnace cooling.

This stress relieving treatment may be omitted where castings are rough machined prior to full annealing or tempering, provided furnace cooling from the tempering temperature is employed.

Where it is desired to adopt other heat treatments particulars are to be submitted for consideration.

Testing and Inspection

503 The tests and inspections described in this Section are to be made, preferably at the place of manufacture prior to despatch, but in the event of any casting proving unsatisfactory in the course of preparation or erection, such casting is to be rejected notwithstanding any previous certificate of satisfactory testing.

504 The tensile strength and ductility are to be determined from standard test pieces, (*see* 507) which are to be prepared from pieces cast on the casting. These pieces are not to be cut from the castings until the heat treatment of such castings has been completed, nor until they have been stamped by the Surveyor. The test pieces are to be stamped by the Surveyor after the heat treatment. All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the conditions herein described are fulfilled.

If for any reason after testing as above, a casting is given a further full annealing or normalising and tempering heat treatment, e.g. after weld repairs, then the original tests are to be disregarded and further complete mechanical tests are to be made.

505 Where the castings are to be used for purposes for which cast iron is ordinarily employed they need not be submitted to tensile and bend tests, but they are to be submitted to the hammering tests specified in 515.

Number of Tests

506 At least one tensile test and one cold bend test are to be taken from each casting. In castings of complex design, referred to in 514, at least two tensile tests and two cold bend tests are to be taken. Where a casting is made from more than one charge of steel, at least four tensile tests and four cold bend tests are to be made upon pieces cast as far apart as possible, some test pieces being taken from as near the top, and others from as near the bottom of the casting as practicable. Where a number of charges are all mixed in one ladle before casting they may be considered as a single charge.

Dimensions of Tensile Test Pieces

507 The standard tensile test pieces are to be turned so as to have a diameter of 14 mm. with a gauge length of 50 mm., or a diameter of 20 mm. with a gauge length of 75 mm., or a diameter of 25 mm. with a gauge length of 90 mm.

Tensile Tests

508 The tensile breaking strength determined from test pieces of standard dimensions is to be between the limits of 41 and 55 kg. per mm.^{2} with an elongation of not less than 20 per cent measured on the standard test piece.

In the case of machinery parts such as boiler mountings, valve chests, and other important machinery castings, the tensile breaking strength is to be between the limits of 44 and 55 kg. per mm.^{2}, with a minimum elongation of 20 per cent measured on a standard test piece.

For cast steel crank webs or combined crank webs and pins, the tensile strength of the material is to be between the limits of 44 and 65 kg. per mm.^{2} and the yield point of the material is to be not less than half the tensile strength. The sum of 0,635 times the tensile strength, in kg. per mm.^{2}, and the percentage elongation is to be not less than 57.

Dimensions of Bend Test Pieces

509 The bend test pieces are to be machined either to a rectangular section 25 mm. by 19 mm. with the edges rounded to a radius of 1,5 mm. or to a diameter of 25 mm.

Bend Tests

510 The bend test pieces are to withstand, without fracture, being bent cold as follows:—

For crank webs and combined crank webs and pins, through an angle of 180°, the internal radius of the bend being not greater than 19 mm.

For other castings, through an angle of 120°, the internal radius of the bend being not greater than 25 mm.

The bending may be performed either by pressure or by blows, and rectangular section test pieces are to be bent over the thinner section.

Additional Tests before Rejection

511 Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the casting, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the casting is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

If the results of retests fail to meet the requirements of 508 and 510 the maker may reheat-treat the casting provided the Surveyor's consent is obtained. Castings so heat-treated are to be presented for further complete mechanical tests. Should the tests and retests again fail to meet the requirements, a further heat-treatment and testing is permitted with the consent of the Surveyor. No casting is to be completely reheat-treated more than twice. If any

test, made after the permissible number of heat treatments, fails to meet the requirements the casting is not to be accepted by the Surveyor.

Low Alloy Steel Castings

512 Where it is proposed to use low alloy steel castings, particulars of the chemical composition, mechanical properties and heat treatment are to be submitted for approval. These castings are to be tested and accepted on the basis of the approved specification and such other tests as may be considered necessary.

Percussive Tests

513 Stern frames cast in one piece are to be let fall on hard ground (excavations being made to take bosses and other projections) after being raised through an angle of 45 degrees. Stern frames cast in more than one piece, rudders, steering quadrants, crossheads and tillers, are to be dropped on hard ground from a height of from 2 metres to 3 metres according to the design, shape, and weight of the casting.

Castings of Complex Design

514 Castings of complex design which would be liable to be deformed if submitted to the drop or percussive test, may be exempt from this test provided two tensile tests and two cold bend tests are made upon pieces taken from positions as far apart as possible on each casting; one tensile test and one bend test should be taken from as near the top and the others from as near the bottom of the casting as practicable.

Hammering Tests

515 All castings are to be slung up and well hammered to satisfy the Surveyors that the casting is sound and without flaw. For large castings the hammer used for this test is to be not less than 3 kg. weight. In the case of castings which are subjected to the percussive tests mentioned in 513, the hammering tests are to be applied after the percussive tests.

Examination and Repair of Castings other than Crankshaft Castings

516 For important castings the Surveyor may request a supplementary examination by magnetic particle, dye penetrant, radiography, ultrasonics or other approved methods of non-destructive testing in order to determine the soundness of the castings. This examination should be carried out at positions mutually agreed by the Surveyor and manufacturer where experience shows that cavities, contraction cracks or other defects are most likely to occur.

When defects are found in a casting the Surveyor is to satisfy himself whether the number and size of the defects are such that the casting can be efficiently repaired by welding. If found repairable the defects are to be removed to his satisfaction and in a form suitable for welding. Generally, castings are to be given a preliminary refining heat treatment prior to carrying out weld repairs. An electric arc welding process is to be used and the weld deposit is to have properties in no way inferior to the parent metal. Welding of the affected parts is to be undertaken by a procedure, the essential elements of which have been tested previously by the manufacturers and approved by the Surveyor. The welding is to be done under cover in positions free from draughts and adverse weather conditions by competent welders with adequate supervision. All welding is to be to the satisfaction of the Surveyors.

The castings are then to be suitably heat treated either by annealing, normalising and tempering or stress relieving at a temperature of not less than 600° C. The type of heat treatment employed will be dependent on the size, position and nature of the defects. On completion of heat treatment, the weld repairs and adjacent metal are to be ground smooth and proved by a suitable method of magnetic particle inspection.

Examination and Repair of Crankshaft Castings

517 All surfaces of crank web and combined web and pin castings are to be examined by magnetic particle methods. For this purpose "as cast" surfaces are to be cleaned and prepared for inspection. Suitable methods include pickling, caustic cleaning, wire brushing, local grinding, shot or sand blasting. Before examination the surfaces should not be hammer peened or treated in any way which may obscure defects. Any irregularities on surfaces which may interfere with the detection of defects should be smoothed by local grinding. It is recommended that a preliminary examination should be carried out prior to final heat treatment but all machined surfaces are to be examined in the finished condition by suitable magnetic particle methods.

Manufacturers are to carry out an ultrasonic test on each casting using competent personnel and reliable and efficiently maintained equipment. They are to provide the Surveyor with a signed statement that such inspection has not reavealed any significant internal defects.

When surface defects are found in a casting these are to be removed by grinding or by chipping and grinding. Complete elimination of the defective material is to be proved by magnetic particle tests. Shallow grooves or depressions resulting from the removal of defects can, at the Surveyor's discretion, be accepted provided these are blended by grinding. Repairs by welding are only permitted subject to the approval of the Surveyor. (*See* Chapter R(H)).

Branding

518 Every casting, after it has withstood satisfactorily the prescribed tests, is to be clearly and distinctly marked by the Surveyor indicating that the casting has complied with the Society's requirements.

Ferritic Steel Castings for Turbines

Process of Manufacture

519 Cast steel turbine cylinders and associated castings may be made from any of the types of steel shown in Table 1. Other suitable low alloy steels, with tensile strengths not exceeding 71 kg. per mm.^{2}, may be used provided details of the proposed composition, heat treatment and mechanical properties are submitted for consideration and approval.

The ladle analysis is to comply with the composition given in Table 1 or with the approved specification.

In all cases the steel used is to be made at an approved works by the open hearth or electric furnace process.

Heat Treatment

520 The castings are to be heat treated in properly constructed furnaces having adequate means of temperature control and the furnace must permit of the whole casting being uniformly heated to the necessary temperature.

All castings are to be fully annealed within a temperature range of 1560° F. (850° C.) to 1740° F. (950° C.), the temperature depending on the composition. Alloy steel castings are subsequently to be normalised followed by tempering at a temperature of 1110° F. (600° C.) to 1200° F. (650° C.), or as otherwise approved.

Removal of Surplus Material

521 Special precautions are to be taken to avoid damage to castings when any surplus metal is removed by flame cutting. Such metal should be removed before final heat treatment of the castings and the affected areas are to be subsequently dressed by grinding or chipping and grinding, and examined by a suitable magnetic crack detection method.

Examination and Repair of Castings

522 Castings are to be examined by the Surveyor on completion of the annealing operation. The surfaces may be pickled but must be suitably cleaned for examination. The surfaces are not to be extensively hammered, peened or treated in any way that may invalidate the inspection.

At changes of section, surfaces are to be smoothed by grinding or coated with a suitable white paint and examined by magnetic crack detection. The Surveyor may request a supplementary examination either by radiography, ultrasonic or other approved methods of non-destructive examination in order to determine the soundness of the casting. The examination should be carried out at positions mutually agreed upon by the Surveyor and manufacturer, where experience shows that cavities or contraction cracks are most likely to occur.

When defects are found in a casting, the Surveyor is to satisfy himself whether the number and size of the defects are such that the casting can be efficiently repaired. If found repairable, the defects are to be removed to his satisfaction and in a form suitable for welding. Welding of the affected parts is to be undertaken by a procedure, the essential elements of which have been tested previously by the manufacturers and approved by the Surveyor. The welding is to be done under cover in positions free from draughts and adverse weather conditions by competent welders with adequate supervision. All welding is to be to the satisfaction of the Surveyors.

The castings are then to be stress relief heat treated at a temperature of not less than 1110° F. (600° C.). Where possible, however, low alloy steel castings are to be repaired by welding before normalising and tempering. On completion of welding and stress relief heat treatment, the welds and adjacent metal are to be smoothed and proved by magnetic crack detection. The stress relieving temperature is not to exceed the temperature at which a casting was previously tempered.

Table 1

Type of Steel	Carbon	Carbon Manganese	½% Mo.	1% Cr. ½% Mo.
Carbon ... ... %	0,25 max.	0,25 max.	0,25 max.	0,25 max.
Manganese ... %	0,5 to 1,0	1,0 to 1,5	0,5 to 1,0	0,5 to 0,8
Silicon ... ... %	0,15 to 0,5	0,15 to 0,5	0,15 to 0,5	0,15 to 0,5
Sulphur ... ... %	0,050 max.	0,050 max.	0,050 max.	0,050 max.
Phosphorus ... %	0,050 max.	0,050 max.	0,050 max.	0,050 max.
Chromium ... %	—	—	—	0,8 to 1,4
Molybdenum ... %	—	—	0,4 to 0,7	0,45 to 0,65

Test Material

523 Unless otherwise approved, test blocks are to be cast integral with the castings and are to be of sufficient size to provide specimens for mechanical tests. Test material is not to be detached from a casting until all heat treatments, other than stress relieving after rough machining, as required by H 421, are completed.

The test blocks are only to be flame cut from castings when the process neither damages the surfaces of the castings, nor affects the characteristics of the test material.

Number of Tests

524 At least one tensile and one bend test piece are to be taken from each casting.

Mechanical Properties

525 Tensile test pieces are to be of the round proportional type with a gauge length of $4\sqrt{A}$. The cross sectional area is not to be less than 1,6 cm^2.

The tensile strength of the steel is to be within the limits given in Table 2 or within the limits of the approved specification. In all cases the elongation is not to be less than 20 per cent and the reduction in area not less than 30 per cent.

TABLE 2

Type of Steel	Range of Tensile Strength
Carbon	44–55 kg. per $mm.^2$
Carbon Manganese ...	44–55 ,, ,, ,, ,,
½% Mo.	44–63 ,, ,, ,, ,,
1% Cr. ½% Mo.	47–71 ,, ,, ,, ,,

526 The bend test piece is to be machined to a diameter of 25 mm. or to a rectangular section 25 mm. by 19 mm. with the edges rounded to a radius of 1,5 mm.

The test piece is to withstand, without fracture, being bent cold through an angle of 120° over a former of radius not more than 25 mm. Bending may be performed either by pressure or by blows and is to be over the thinner section for rectangular section test pieces.

Additional Tests before Rejection

527 Where either the tensile test or bend test or both fail and the Surveyor considers that the results may not fairly represent the quality of the casting, two additional test pieces may be taken. If possible one is to be taken from the test block used for the original tests and the second from another test block. In such cases the quality of the casting is to be judged on the results of two retests and not on the results of the original tests which failed.

If the results of the mechanical tests and retests fail to meet the requirements of 525 and 526, the manufacturer may reheat-treat the casting provided the Surveyor's consent is obtained. Castings so treated are to be presented for further complete mechanical tests.

Branding

528 Every casting to be marked in accordance with 518.

CAST STEEL PROPELLERS AND PROPELLER BLADES

Process of Manufacture

529 Propellers and propeller blades may be cast in a carbon steel, a low alloy steel or a stainless steel. The steel is to be made by the acid or basic open hearth, electric furnace, or other approved process.

Ferritic steel for propellers and propeller blades intended for icebreakers or ships with Class 1* and Class 1 ice strengthening (see H 8) is to be made by an electric furnace process and is to be grain-controlled.

530 The specified composition, heat treatment and mechanical properties of the steel are to be submitted for approval.

Heat Treatment

531 Each casting is to be heat treated in a properly constructed furnace having adequate means of temperature control and of a size permitting the whole casting to be uniformly heated to the necessary temperature.

Test Material

532 The foundry is to provide the Surveyor with a statement giving the ladle analysis of the steel and general particulars of the heat treatment of each casting.

533 Material is to be provided for test purposes at the hub of each propeller casting and on the flange of each propeller blade casting. This test material is not to be detached from the casting until the heat treatment has been completed. It is then to be stamped for identification by the Surveyor and is to be removed by a method which does not damage the casting or affect the mechanical properties of the test material.

Number of Tests

534 All test pieces are to be selected by the Surveyor and tested in his presence.

At least one standard tensile test piece and one standard bend test piece are to be machined from the test material.

At least two impact test pieces are to be machined from the test material for the following types of castings:—

(*a*) Carbon and low alloy steel castings intended for icebreakers and ships with Class 1* and Class 1 ice strengthening. The temperature of test is to be —10° C.

(*b*) Stainless steel castings, excepting austenitic steel castings, intended for any type of ship. The temperature of test is to be —10° C. for icebreakers and ships with Class 1* and Class 1 ice strengthening and 0° C. for other ships.

Impact tests are not required from carbon or low alloy steel castings intended for general service or from stainless steel castings of the austenitic type regardless of service.

The impact test pieces are to be of the Charpy V-notch type having the dimensions and tolerances quoted in P 207. The impact tests are to be made in accordance with the requirement of the last paragraph of P 207 at the test temperatures given above.

Mechanical Properties

535 The results of the tensile and bend tests are to comply with the approved specification. The average energy for fracture of the two impact test pieces is to be not less than 2,1 kg.m.

Additional Tests Before Rejection

536 Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the casting, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the casting is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

Where the average result of the impact test fails to meet the required value, two further test pieces may be prepared for each test piece which gave a low result. These further test pieces are to be machined and tested in accordance with 534. When duplicate tests are made for both of the original impact test pieces, the average of the energy values of the four further tests is to be not less than 2,1 kg.m. When duplicate tests are made for only one of the original test pieces, the results of the two further tests are to be added to the original single energy value which was satisfactory and the average of the three values is to be not less than 2,1 kg.m.

For martensitic 13% chromium stainless steel propeller and propeller blade castings, special consideration will be given to their acceptance in cases where the average energy is not less than 1,4 kg.m.

537 If the results of all or any of the mechanical tests on which the quality of the casting is judged, fail to meet the requirements, the casting may be re-heat treated provided the Surveyor's consent is obtained. Castings so heat treated may be presented for further complete mechanical tests. Should the results of the tests again fail to meet the requirements, the procedure may be repeated with the consent of the Surveyor.

No casting is to be re-heat treated more than twice. If any test, made after the permissible number of heat treatments, fails to meet the requirements, the casting is to be rejected by the Surveyor.

Examination of Castings

538 Castings are to be sound and free from detrimental defect.

539 The Surveyor is to examine the castings before despatch from the foundry. The surfaces of the blade roots are to be dressed smooth and examined by a magnetic particle test, in his presence. Where the casting is of austenitic stainless steel, these regions are to be subjected to a dye-penetrant test. Where the Surveyor has doubts regarding the soundness of other regions of a casting he may require a supplementary examination of these regions by magnetic particle inspection or other approved means of non-destructive testing.

No repair is to be made by welding without the prior approval of the Surveyor. Where it is proposed to repair minor surface defects by welding, particulars of the defects, the weld procedure, the electrodes and the heat-treatment are to be submitted for approval.

In the event of a propeller or a propeller blade casting proving unsound during inspection following machining, it is to be rejected notwithstanding any previous certificate of satisfactory test and inspection.

Branding

540 Each casting, after it has withstood satisfactorily the prescribed tests and inspection, is to be clearly marked by the Surveyor indicating that it complies with the requirements of the Society.

Section 6

INGOT STEEL FORGINGS

Large Carbon Steel Forgings

General

601 These requirements apply to important ship and machinery components of wrought carbon steel and having a ruling section greater than 150 mm. Typical items are as follows:—

(a) Stern frames, "A" brackets, rudder stocks, main-pieces and arms and other important ship forgings.

(b) Crank and other shafting, forged slabs for crank webs, connecting rods, piston rods, crossheads and other important machinery forgings.

(c) Crank webs made from rolled slabs and straight shafts, rudder stocks, etc., made from rolled bar.

(*See* this Section for turbine rotors and subsequent Sections for seamless drums and gearing forgings.)

Process of Manufacture

602 The forgings are to be manufactured from killed steel made at an approved works by the open hearth process, acid or basic, an electric furnace process or other approved process.

603 The forgings are to be made from ingots cast in chill moulds with the larger cross-section uppermost and with efficient feeder heads. They are to be gradually and uniformly hot worked from sound ingots. Adequate top and bottom discards are to be made to ensure freedom from piping and harmful segregation in the finished forgings.

Forgings are to be brought as nearly as possible to the finished shape and size by hot working. Where practicable they are to be worked so as to cause metal flow in the most favourable direction having regard to the mode of stressing in service.

Unless otherwise approved the maximum sectional area of any part of a forging (as forged) is not to exceed:—

1/3A where the length of any section is greater than its diameter.

2/3A where the length of any section is less than its diameter (e.g. a collar).

A is average sectional area of the ingot or of the ingot after upsetting if such an operation is involved.

Disc or ring type forgings are to be made from cylindrical pieces which have been hot cut or machined from a bloom or billet. The thickness of any part of a disc (as forged or as stamped) is to be not more than one half of the length of the piece from which it was formed.

In the case of the combined web and pin forgings for semi-built crankshafts the forging procedure is to be submitted for approval. It is recommended that these forgings be made by a folding method. Other methods which can be shown to produce sound forgings with satisfactory mechanical properties will be considered but where the gapping method is used for cranks having a pin diameter exceeding 500 mm this will only be accepted provided that an upsetting operation is included in the manufacturing sequence. In general the amount of work during the upsetting operation is to be such that the reduction in the original length of the ingot (after discard) or bloom is not less than 50%.

Composition of the Steel

604 The forgemaster is to provide details of the cast analysis of the steel used for each forging and the general details of the heat treatment.

The composition of the carbon steel is restricted as follows:—

Carbon	...	0,50% max.
Silicon	...	0,10% to 0,45%
Manganese	...	0,30% to 1,00%
Sulphur	...	0,050% max.
Phosphorus	...	0,050% max.

Where it is proposed to use a carbon steel forging in welded construction for ship or machinery, the carbon content of the steel is generally not to exceed 0,23 per cent. In the order for the forging it is to be stated that the steel is to be of weldable quality and the maximum carbon content is also to be quoted. Alternatively, a particular grade of steel that has been approved for the purpose may be specified in the order.

Heat Treatment

605 Forgings are to be heat treated in properly constructed furnaces which are efficiently maintained and have adequate temperature control. If a forging is subsequently heated for any further forging work, it is again to be properly heat treated.

The forgings are to be heated to a uniform temperature above the upper critical point to refine the grain and are to be:—

(a) fully annealed by cooling slowly in the furnace in a uniform manner,

or (b) normalised by cooling in air followed by a tempering treatment to relieve internal stresses if the diameter of the body of the forging is equal to or greater than the values given in Table 1. Smaller diameter forgings may also be tempered after the normalising heat treatment at the option of the forgemaster,

or (c) hardened by quenching in oil or by other recognised method followed by tempering. However, hardening by any method is only to be adopted with the consent of the Surveyor. Unless otherwise agreed, forgings are to be rough machined prior to the hardening heat treatment.

TABLE 1

DIMENSIONS OF FORGINGS TO BE TEMPERED AFTER NORMALISING

% CARBON CONTENT OF STEEL		EQUIVALENT DIAMETER OF BODY OF FORGING
Over	*Up to and including*	
0,40	0,50	380 mm
0,35	0,40	510 ,,
0,30	0,35	710 ,,
0,25	0,30	890 ,,
	0,25	1015 ,,

Flame Cutting of Forgings

606 The shaping of forgings or thick slabs by flame cutting is to be undertaken in accordance with a procedure approved by the Surveyor. Where possible, flame cutting is to be carried out before the heat treatment operation of 605. Pre-heating is to be employed when necessitated by the thickness and/or composition of the steel.

For machinery parts that are subjected to cyclic stress during service, a depth of at least 12,5 mm. is to be removed by machining from flame cut surfaces. If required by the Surveyor, selected areas of such machined surfaces are to be prepared and then examined by magnetic crack detection or other equivalent method to his satisfaction.

Provision of Test Pieces

607 Sufficient material of not less than the sectional dimensions of the body is to be formed integral with forgings and is to be used for test purposes. This material is not to be removed from a forging until the heat treatment is completed except where an alternative procedure has been specially approved, and the Surveyor has identified by stamp marks the test portions and the forgings.

608 The tensile strength and ductility of the material of each forging is to be determined from standard test pieces which are to be machined from portions cut longitudinally or in the direction of principal grainflow. Where material for testing cannot reasonably be provided from the longitudinal direction, the test pieces may be cut in a transverse direction. Test pieces are to be taken transversely from slabs for crank webs.

Test portions are not to be forged down and neither these nor the test pieces machined therefrom are to be treated in any way which may influence the properties of the material.

Number of Tests

609 At least one tensile and one cold bend test piece are to be taken from each forging or multiple forging. In the case of forgings or multiple forgings exceeding both 3000 kg. in weight and 2,44 metres in length, one tensile test and one cold bend test piece are to be taken from each end of each forging or multiple forging.

Dimensions of Test Pieces

610 Tensile test pieces are to be machined to a form which complies with an appropriate National Standard, providing the diameter within the gauge length is not less than 12,5 mm. The gauge length may be either 4 or 5,65 times the square root of the cross sectional area of the test section. Test pieces of non-standard dimensions or of smaller size may only be used with the consent of the Surveyor and in special cases where the dimension of the forging will not permit the use of the required test pieces. In such cases the test piece is to be of the largest practicable size associated with a standard gauge length.

611 The bend test pieces are to be machined to a rectangular section of either 25 mm. wide by 19 mm. thick where the specified minimum tensile strength of the steel does not exceed 57 kg. per mm.^{2} or 19 mm. wide by 9,5 mm. thick where the specified minimum tensile strength of the steel is in excess of 57 kg. per mm.^{2}. The edges of the test pieces may be rounded to a radius of not more than 1,5 mm. in each case.

Test Requirements

612 Tensile tests, which are to be made in the presence of the Surveyor or an authorised deputy, are to be carried out by competent personnel and in an approved machine of adequate capacity. The machine is to be maintained in an efficient and accurate condition, and is to be checked and calibrated at suitable intervals agreed by the Society.

613 For crank webs (*see* H 208 and H 609) and other parts where minimum yield stresses are specified, these stresses are to be determined, using a moderate rate of loading, by the drop-of-the-beam of a lever type testing machine or the hesitation of the gauge needle of a hydraulic testing machine. Where such methods are unacceptable to the Surveyor an extensometer or dividers may be used. In the latter case the yield stress is to be taken as the stress corresponding to an increase of 1/200 of the original gauge length.

614 Forgings are to have tensile strengths between 44 and 71 kg. per mm.^{2}; the specified range of tensile strength for any forging is not to exceed 7,9 kg. per mm.^{2}. Where tensile test pieces are taken from each end of a forging or multiple forging the test results are not to vary by more than 6,3 kg. per mm.^{2} in addition to complying with the previous requirements.

Screwshaft forgings are, in general, to be restricted to a range of tensile strength of 44 to 52 kg. per mm.^{2}.

Sternposts, propeller posts, rudders and other important ship forgings, and propeller nuts may be made of a specially soft ingot steel, the tensile strength being within the limits of 35 to 41 kg. per mm.^{2}.

The percentage elongation of tensile test pieces measured after fracture is not to be less than the minimum given in Table 2, appropriate to the tensile strength of the steel.

Where it is proposed to use steel of higher carbon content than that permitted in 604 and/or a higher tensile strength than specified above, the details are to be submitted for approval.

615 Bend test pieces are to withstand, without fracture, being cold bent through an angle of 180° to an internal radius (or round a former having a radius) not greater than that specified in Table 3 according to the tensile strength. The test pieces are to be bent over the thinner section.

The bending may be done by pressure or blows.

Additional Tests before Rejection

616 Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the forging, two further test pieces are to be taken for each piece that failed. In such cases the quality of the forging is to be judged by the result of the retests and not by the original test or tests which failed.

617 If the results of mechanical tests and retests on a forging fail to meet the requirements of 613 to 616 inclusive, the maker may reheat-treat the forging providing the Surveyor's consent is obtained. Forgings so heat treated are to be presented for further complete mechanical tests. Should the tests and retests again fail to meet the requirements, a further heat treatment is permitted with the consent of the Surveyors. No forging is to be completely reheat-treated more than twice. If any test, made after the permissible number of heat treatments, fails to meet the requirements the forging is not to be accepted by the Surveyor.

Inspection of Forgings

618 The Surveyor is to examine each forging before despatch by the forgemaster. Forgings are to be sound and free from cracks, harmful flaws and segregation.

TABLE 2

TENSILE PROPERTIES OF CARBON STEEL FORGINGS

Minimum Elongation Per Cent

Actual Tensile Strength kg. per mm.^{2}	$L = 4\sqrt{A}$		$L = 5{\cdot}65\sqrt{A}$	
	Longitudinal or in the Direction of Principal Grain Flow	Transverse or Across the Direction of Principal Grain Flow	Longitudinal or in the Direction of Principal Grain Flow	Transverse or Across the Direction of Principal Grain Flow
35 to 41	31	25	27	21
over 41 ,, 44	29	24	25	20
,, 44 ,, 47	28	23	24	19
,, 47 ,, 50	27	21	23	18
,, 50 ,, 54	26	20	22	17
,, 54 ,, 57	25	19	21	16
,, 57 ,, 60	23	18	19	15
,, 60 ,, 63	22	17	18	14
,, 63 ,, 66	21	16	17	13
,, 66 ,, 71	19	14	15	11

TABLE 3

BEND TESTS FOR CARBON STEEL FORGINGS

Actual Tensile Strength kg. per mm.²	Maximum Internal Radius of bend or Radius of Former	
	Longitudinal or in the Direction of Principal Grain Flow	Transverse or Across the Direction of Principal Grain Flow
Up to 50	$\frac{1}{3}$T	$\frac{2}{3}$T
over 50 to 57	$\frac{1}{2}$T	T
,, 57 ,, 63	$\frac{2}{3}$T	$1\frac{1}{3}$T
,, 63 ,, 71	T	2T
	Where T=thickness of test piece	

In the case of forgings for crankshafts which have finished pin or journal in excess of 510 mm. diameter, the forgemaster is to carry out an ultrasonic test on each forging, using competent personnel and reliable and efficiently maintained equipment.

In the event of any forging proving unsound during subsequent machining, erection or trials, such forging is to be rejected notwithstanding any previous certificate of satisfactory test and inspection.

Branding

619 Every forging, after it has withstood satisfactorily the prescribed tests and inspection, is to be clearly and distinctly marked by the Surveyor indicating that the forging has complied with the requirements of the Society.

Small Carbon Steel Forgings

General

620 This section covers small carbon steel forgings made from billet or bar and intended for important stressed applications, e.g. fuel pump bodies, flanges, small diameter shafts, deck fittings, etc.

621 The steels of billets or bars used for the manufacture of the forgings are to comply generally with the requirements of 602, 603 and 604. Where the billets or bars are supplied to a forge that is not an integral part of an approved steelworks, the Surveyor at the forge is to be provided with a certificate that states the name of the manufacturer of the billets or bars; the process of manufacture of steel; the cast number and the ladle analysis.

Heat Treatment

622 Forgings are to be heat treated in accordance with 605.

Provision of Test Pieces

623 Unless otherwise agreed by the Surveyor, material for test purposes is to be provided in accordance with 607. Where a number of individual forgings of the same type are produced, a system of batch testing may be adopted by the Surveyor. In such cases forgings are to be presented for test and inspection in groups of the same cast and the same heat treatment batch.

Test Requirements

624 Where a system of batch testing is adopted, the hardness of each forging is to be determined including those from which material is to be cut for the provision of tensile and bend test pieces. The hardnesses of the forgings are to comply with a specification approved by the Surveyor before manufacture of the parts.

Tensile and bend test pieces are to be prepared and tested in accordance with 610, 611 and 612. The results of the tests and conditions of retest are to comply with 613 to 617 inclusive.

Quantity Production

625 Where small and identical forgings are produced in large quantities, the Surveyor may adopt a suitable system of quality control provided it is approved and the required standard of inspection is maintained by the firm.

Inspection of the Forgings and Branding

626 The Surveyor is to examine forgings before despatch. The forgings are to be sound and free from cracks and harmful flaws and segregation. In the event of any forging proving unsound during machining or erection, such forging is to be rejected notwithstanding any previous certificate of satisfactory test and inspection.

Forgings which have withstood satisfactorily the prescribed tests and inspections are to be marked in accordance with 619.

Alternative Specifications

627 Where it is proposed to use a steel of higher carbon content than that permitted in 604 and/or of higher tensile strength than that specified in 614, the details are to be submitted for approval.

Ferritic Steel Forgings for Turbines, Compressors and Turbine Driven Generators

General

628 Ferritic steel used for the manufacture of forgings for turbine rotors, discs and spindles, turbine driven generators rotors and compressor rotors is to be made at an approved works by the open hearth, electric furnace or other approved process.

629 Ingots are to be cast in chill moulds with the larger section uppermost, and with efficient refractory feeder heads.

630 The forgings may be made of carbon steel or alloy steel. The composition of the steel is to be restricted as follows:—

Carbon	0,45% maximum
Silicon	0,15% to 0,45%
Sulphur	0,050% maximum
Phosphorus ...	0,050% maximum

Where mechanical tests are required from forgings in either the radial or the tangential direction or both, the sulphur and the phosphorus contents of the steel are not to exceed 0,040 per cent each.

Specifications of alloy steel forgings giving the proposed chemical composition, heat treatment and mechanical properties are to be submitted for approval with the plans of the components.

When it is proposed to use rotors of welded construction the compositions of the steel for the forgings are to be submitted for special consideration. These are to comply with the above limits of composition except that generally the carbon content is not to exceed 0,25 per cent.

631 The steelmaker is to provide details of the cast analysis of the steel used for each forging and the general details of heat treatment.

632 All forgings are to be sound and free from harmful defect. Forgings may be rejected if harmful defects are revealed during machining, notwithstanding acceptance during earlier stages of manufacture.

633 Orders and drawings for rotor forgings are to state whether the rotor is intended for propulsion or auxiliary machinery, and the shaft horse power of auxiliary turbines. In the case of a rotor which is to be tested for thermal stability the maximum operating temperature and the proposed test temperature are also to be stated.

Manufacturing of Forgings

634 Thermal treatments of the steel are to be such as to avoid the formation of hair line cracks.

635 The forgings are to be gradually and uniformly forged from sound ingots from which at least 5 per cent of the total weight of the ingot is removed from the bottom and not less than the following percentages of the total weight from the top of the ingot:—

Weight of ingot	*Minimum top discard*
Below 2000 kg. ...	15 per cent
2000 to 5000 kg. ...	18 ,, ,,
5000 to 10000 kg. ...	22 ,, ,,
Over 10000 kg. ...	25 ,, ,,

636 For rotor forgings the sectional area of any part (as forged) is not to exceed one half of the average sectional area of the ingot. Where an upsetting operation is included in the manufacturing procedure the above requirement is to apply to the sectional area of the upset bloom and not to the ingot.

637 For spindle forgings the sectional area of any part (as forged) is not to exceed one third of the average sectional area of the ingot except at collars where the area is not to exceed two thirds of the sectional area of the ingot.

638 Turbine discs are to be forged or stamped from cylindrical pieces which have been hot cut or machined from a bloom or a billet. The thickness of any part of a disc (as forged or as stamped) is to be not more than one half of the length of the piece from which it was formed.

Heat Treatment

639 Forgings are to be carefully heat treated in properly constructed furnaces. At a suitable stage of manufacture they are to be re-heated above the upper critical point to refine the grain, cooled in an approved manner and then tempered to produce the desired mechanical properties.

Where forgings receive their main heat treatment prior to machining they are to be stress relieved at an intermediate machining stage.

The tempering and stress relieving temperatures are to be not less than 550° C. (1020° F.) in the case of carbon steels and 600° C. (1110° F.) in the case of alloy steels. The holding times and subsequent cooling rates are to be such that the forging in its final condition is free from harmful residual stresses.

The stress relieving temperature is not to exceed the temperature at which the forging was previously tempered.

Number of Tests

640 Sufficient material is to be left on forgings to provide specimens for mechanical tests. Excess test material is not to be completely severed from a forging until all the required mechanical tests have been completed with satisfactory results.

Test pieces are to be machined from pieces which are not to be cut from the forging until all heat treatment has been completed. In this connection a thermal stability test does not form part of the heat treatment of a turbine rotor forging.

641 At least one longitudinal tensile and one cold bend test piece are to be taken to represent the material of each forging (or multiple forging) excluding discs. In the case of forgings (or multiple forgings) exceeding both 3000

kg. in weight and 1,83 metres in length not less than one tensile and one cold bend test are to be taken from each end of each forging (or multiple forging).

642 For rotor forgings of all main propulsion machinery and of auxiliary turbines exceeding 1500 s.h.p. tangential and, where dimensions permit, radial tensile and bend tests are also to be taken from the end of the body corresponding to the top end of the ingot.

643 For each turbine disc, at least one tensile and one bend test piece are to be cut in a tangential direction from material at the hub.

Mechanical Properties

644 Tensile test pieces of the round proportional type are to be used with a gauge length of $4\sqrt{A}$. For longitudinal and tangential tests the cross sectional area is to be not less than 1,6 cm.^{2} and for radial tests not less than 0,65 cm.^{2}

For carbon steel forgings the tensile strength is to be specified as a range of 7,9 kg. per mm.^{2} within the limits of 44 to 71 kg. per mm.^{2} For alloy steel rotor forgings the specified range is to be 12,6 kg. per mm^2 within the limits of 44 to 91 kg. per mm.^{2} For discs and other alloy steel forgings the specified range is also to be 12,6 kg. per mm.^{2} within the limits of 44 to 107 kg. per mm.^{2}

In all cases the tensile strength of the steel is to be within the specified and approved range.

Where more than one tensile test piece is taken from a single forging, the tensile strengths are to be within the specified range but for alloy steels these are not to differ by more than 9,5 kg. per mm.^{2}

645 Unless otherwise specified and approved, the yield stress or 0,5 per cent proof stress, as appropriate for the type of steel, is not to be less than 50 per cent of the actual tensile strength for normalised material and not less than 60 per cent of the actual tensile strength for low alloy material in the quenched and tempered condition.

646 The reductions of area at fracture as determined on tensile test pieces are not to be less than:—

35% for longitudinal test

30% for tangential tests

20% for radial tests.

647 The percentage elongations at fracture of tensile test pieces are to comply with the requirements given in Table 4.

648 If the percentage of elongation of any tensile test specimen is less than that prescribed in Table 4, and any part of the fracture is outside the middle half of the gauge length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

649 Bend test pieces are to be machined to a section of 19 mm. by 9,5 mm. The test pieces are to be bent cold without fracture to angles of not less than 180° for a longitudinal test piece; 150° for a tangential test piece; and 120° for a radial test piece.

The maximum radius of the formers is given in Table 4.

650 Where either the tensile test or bend test or both fail, and the Surveyor considers that the results may not fairly represent the quality of the forging, two additional test pieces may be taken from a similar part of the forging if requested by the maker. In such cases the quality of the forging is to be judged on the results of the two retests and not on the results of the original tests that failed.

651 If the results of mechanical tests and retests on a forging fail to meet the requirements of 644 to 650 inclusive, the maker may reheat-treat the forging providing the Surveyor's consent is obtained. Forgings so treated are to be presented for further complete mechanical tests.

652 Alternative requirements of National Standard and other specifications, which provide reasonable equivalents in mechanical properties, may be accepted if approved. Impact tests in place of bend tests may also be accepted if approved.

Additional Inspections

653 Rotor forgings for propulsion machinery and for auxiliary turbines exceeding 1500 s.h.p. are to be hollow bored for internal examination. The surfaces of the bores are to have a fine, smooth finish. The Surveyor is to be provided with an optical instrument of suitable magnification to examine the bores.

At the discretion of the Surveyor, alternative methods of proving the internal soundness of such forgings may be accepted.

654 The end faces of rotor forgings are to be machined to a fine smooth finish at the forge for the purposes of examination.

655 The end faces of the boss and the bore surface of each turbine disc are to be machined to a smooth finish and examined by a suitable method of magnetic crack detection.

Stability Testing of Turbine Rotors

656 Thermal stability tests after heat treatment and rough machining of the turbine rotors referred to in H 410 are to be undertaken in properly constructed furnaces, using accurate and reliable measuring equipment. Each test is to be carried out in accordance with the following recommended procedure:—

(*a*) Five bands are to be machined concentric with the axis of rotation. Two of these are to be reference bands and are to be positioned at or near the locations of the bearings. The remaining three bands are to be test bands located one as near as possible to the mid-length, and the other two near each end of the body. Where the length of a rotor is such that five bands cannot be provided, alternative proposals are to be submitted to the Surveyor for his approval.

(*b*) Four positions, 90° apart, are to be stamped A, B, C and D on the coupling end of the rotor.

(*c*) The whole of the body and as much of the shaft at either end as will include the positions of the glands are to be enclosed in the furnace. In the case of a rotor having an overhung astern wheel, the astern wheel is also to be enclosed in the furnace during the first test. (*See* H 410.)

(*d*) The rotor is to be rotated at a uniform and very slow speed.

(*e*) The deflections at all bands are to be recorded at the A, B, C and D positions. Initial cold readings are to be taken prior to heating.

(*f*) The rotor is to be heated uniformly and slowly. Temperatures are to be recorded continuously at the surface of the rotor and if practicable in the bore at the mid-length of the body. Under no circumstances is the surface temperature to exceed the temperature at which the rotor was tempered. During heating the rate of rise of temperature is to be such as to avoid excessive temperature gradients in the rotor.

(*g*) The maximum or holding temperature is to be not less than 28° C. (50° F.) above the maximum operating temperature of the rotor. For the purposes of the test the holding period is to start when the rotor has attained a uniform and specified temperature. The rotor is to be held under the specified temperature conditions until not less than three consecutive hourly readings of deflections show the radial eccentricity to be constant within 0,006 mm. on all test bands.

TABLE 4

Minimum Specified Tensile Strength	Minimum Percentage Elongation for gauge length of $4\sqrt{A}$*			Maximum radius of former in millimetres for bend test					
				180°		150°		120°	
Kg. per mm.²	L.	T.	R.	L.	T.	R.			
44	28	23	20	9,5	9,5	9,5			
47	28	23	20	9,5	9,5	9,5			
55	25	20	18	12,5	12,5	12,5			
63	22	18	16	19	19	19			
71	20	16	14	19	19	19			
79	18	14	12	19	19	—			
87	17	13	—	25	25	—			
94	17	12	—	25	25	—			

L.—For longitudinal tests.
T.—For tangential tests.
R.—For radial tests.
Intermediate values are to be obtained by interpolation.

* A is the cross sectional area of the tensile test piece.

Yield stress or 0,5% proof stress (*See* 645)

Not less than 50% of the actual tensile strength for normalised material.

Not less than 60% of the actual tensile strength for low alloy material in the quenched and tempered condition.

Reduction of Area (*See* 646)

Not less than 35% for longitudinal tests.
" " " 30% for tangential tests.
" " " 20% for radial tests.

(*h*) The turbine rotor is to be rotated during cooling until the temperature is not more than 100° C. (212° F.). The rate of cooling is to be such as to avoid excessive temperature gradients in the rotor.

(*i*) Final cold readings are to be taken.

657 The movements of the axis of the rotor in relation to the reference bands are to be determined from polar plots of the deflection readings.

The radial movement of the shaft axis as determined by the difference between the final hot and the final cold movements is not to exceed 0,025 mm. on any one band.

As verification that test equipment and conditions are satisfactory it is required that similar determinations of differences between initial cold and final cold movements do not exceed 0,025 mm. on any one band.

If the results of the test on a rotor fail to meet either or both of the above requirements, the test may be repeated if requested by the maker and agreed by the Surveyor.

658 In the case of a rotor failing to meet the requirements of a thermal stability test, the rotor is deemed unacceptable. Proposals for the rectification of thermal instability of a rough machined rotor are to be submitted for special consideration.

Branding

659 Every forging to be marked in accordance with 619.

Hot Rolled Steel Bars, from which Shafts and other parts are machined

660 Hot rolled steel bar intended for propeller and straight shafting, rudder stocks, shafts for electric motors, generators and other suitable applications is not to exceed 250 mm. in diameter and is to comply generally with the requirements given in 602 to 619. One tensile and one bend test are to be taken from each bar, as supplied. If the weight of an individual bar is in excess of 1000 kg., tensile and bend tests are to be taken from each end.

Steel Forgings for Screwshafts Intended for Ice Breaking Service

General

661 Screwshafts intended for icebreakers or ships with Class 1* and Class 1 ice strengthening (see H 8) are to be hot formed from forging quality ingots of a grain-controlled, electric furnace steel. Steel made by other approved processes will be accepted provided there is evidence that the mechanical properties required in 666 can be obtained from the ruling section of the forging.

662 A mild steel having a range of tensile strength of 44—52 kg. per mm.^{2} or a suitable low alloy steel is to be used. The specified composition of the alloy steel and the minimum mechanical properties are to be submitted for approval. The carbon content of the alloy steel is not to exceed 0,25%.

Manufacture and Heat Treatment

663 The forgings are to be made in accordance with the requirements of 603. They are to be heat treated as required by 605 and according to method (b).

Number of Tests

664 Tensile and bend test pieces are to be provided as in 607 to 611 inclusive. In addition, two Charpy V-notched impact test pieces are to be prepared from test material located at the propeller end of each shaft forging. The test pieces are to be cut in the longitudinal direction and from near the surface of the forging. The pieces are to be machined to the dimensions and tolerances quoted in P207, the notch being transverse to the direction of the grain.

665 The tensile and bend tests are to be made in accordance with 612. The impact test pieces are to be tested at a temperature of —10° C. and as detailed in the last paragraph of P207.

Mechanical Properties

666 The tensile strength of each forging is to be between 44—52 kg. per mm.^{2} or as otherwise approved. Where tensile test pieces are taken from each end of a forging, the test results are not to vary by more than 6,3 kg. per mm.^{2}. The bend test is to comply with 615 or as otherwise approved. The average energy for fracture of the two impact test pieces is to be not less than 2,1 kg.m.

Additional Tests Before Rejection

667 If the tensile test or bend test results fail to meet the requirements, and the Surveyor considers the fractured test piece or test pieces or the results obtained therefrom do not fairly represent the quality of the forging, two further test pieces are to be taken for each piece that failed. In such cases the quality of the forging is to be judged on the results of the re-tests and not by the original test or tests which failed.

Where the average result of the impact tests fails to meet the required value, two further test pieces may be prepared for each test piece which gave a low result. These further test pieces are to be machined and tested in accordance with 664. When duplicate tests are made for both of the original impact test pieces, the average of the energy values of the four further tests is to be not less than 2,1 kg.m. When duplicate tests are made for only one of the original

test pieces, the results of the two further tests are to be added to the original single energy value which was satisfactory and the average of the three values is to be not less than 2,1 kg.m.

668 The conditions for re-heat treatment and presentation of a forging for further mechanical tests are quoted in 617.

Inspection and Branding

669 Inspection of the screwshaft forgings and branding are detailed in 618 and 619.

Section 7

SEAMLESS STEEL DRUMS FOR BOILERS

Process

701 The steel is to be made by the open hearth process, acid or basic.

Discard

702 Sufficient discard shall be made from the top and bottom of each ingot to ensure soundness in the portion used for forging, and sulphur prints may be taken to demonstrate that this condition has been fulfilled.

Forging

703 The forging shall be made from a solid cast ingot, punched, bored or trepanned, or alternatively hollow cast ingots may be used. The resultant wall in the case of the solid cast ingot, or the wall of the hollow ingot, as cast, shall be reduced in thickness by at least two-thirds in the process of forging.

The Committee will be prepared to give consideration to the circumstances of any special case.

Heat Treatment and Testing

704 Sufficient material shall be left on each end of each forging to enable tangential tests to be taken. These tests are to consist of one tensile test and one bend test from each end. In the case of open-ended drums the test material shall not be parted off before heat treatment, but, if the drums are closed in, the test rings may be parted prior to this operation; subsequently the test rings and the forging shall be simultaneously heat treated in the same furnace.

If desired, test pieces may be heated for the purpose of straightening, but this operation must not cause any alteration in the sectional area of the test pieces, which are subsequently to be heat treated simultaneously with the drum.

Tensile Tests

705 The tensile breaking strength is to be between the limits of 44 and 63 kg. per mm.^{2}, but the difference in the tensile strengths at each end of a forging is not to exceed 6,3 kg. per mm.^{2}

The percentage of elongation measured on a standard test piece (*see* P 608) is to be between 29 and 17, and in no case is the sum of 0,635 times the tensile breaking strength and corresponding elongation to be less than 57.

Bend Tests

706 Test pieces 25 mm. by 19 mm. are to be capable of being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than that specified below:—

Up to 50 kg. per mm.^{2}	6 mm.
Above 50 kg. and up to 56,5 kg. per mm.^{2} ...	9,5 mm.
Above 56,5 kg. and up to 63 kg. per mm.^{2} ...	16 mm.

Retesting

707 Should either the tensile test or the bend test fail, two further specimens may be tested and if the results obtained from both are satisfactory the forging shall be accepted. In the event of either or both retests failing, the forging may be again heat treated and re-presented for test.

Section 8

REDUCTION GEAR PINIONS AND GEAR WHEELS

General

801 Steels used for pinions, pinion sleeves and wheel rims are to comply with the following requirements. Steels for other parts used in the construction of gearing are to comply with the requirements of P 3, P 5 or P 6 as may be applicable.

The steel is to be made by the acid open hearth, electric furnace or other approved process and is to contain not more than 0,04 per cent of sulphur or phosphorus.

Ingots are to be cast in chill moulds with the larger diameter or cross section uppermost, and with efficient refractory feeder heads.

A certificate giving the actual chemical analysis of the steel is to be provided in all cases.

802 Specifications for materials of pinions, pinion sleeves, wheel rims, flexible couplings and quill shafts giving chemical analysis, heat treatment and mechanical properties are to be submitted for approval with the plans of gearing, as required by H 503.

803 All forgings are to be sound and free from defects. Forgings may be rejected after the cutting of teeth if defects are then revealed, notwithstanding acceptance during earlier stages of manufacture.

Pinions

Materials

804 Pinions are to be made from approved alloy steels which in the heat treated condition have tensile strengths between 63 and 120 kg. per mm.^{2} The specified range of tensile strength is not to exceed 9,4 kg. per mm.^{2} for any forging (*see also* H 502).

Any of the following type steels will be accepted for this service within the range of tensile strengths for which they are suitable:—

3% Ni
3½% Ni
1¾% Ni+Cr+Mo
2½% Ni+Cr+Mo
3% Ni+Cr+Mo
4¼% Ni+Cr+Mo
3% Cr+Mo

NOTE.—The percentage figures are applicable to the first element only: for instance 1¾% Ni+Cr+Mo is to be interpreted as a steel having a nominal Ni content of 1¾% with, in addition, appropriate contents of Cr and Mo.

Where it is desired to use other alloy steels or case-hardening steels full details are to be submitted for consideration.

Manufacture of Forgings

805 The forgings are to be gradually and uniformly forged from ingots from which at least 5 per cent of the total weight of the ingot is removed from the bottom and not less than the following percentage of the total weight from the top of the ingot:—

Weight of Ingot	*Minimum top discard*
Below 2000 kg.	15 per cent
2000 to 5000 kg.	18 ,, ,,
Over 5000 kg.	25 ,, ,,

806 The sectional area of any part of the forging (as forged) is not to exceed:—

One half of the sectional area of the ingot where the length at any diameter is greater than its diameter or for any part in which teeth are to be cut.

Two thirds of the sectional area of the ingot where the length at any diameter is less than its diameter, e.g., a collar.

Sleeves are to be hollow forged or hollow rolled where practicable.

807 The forgings are to be made with sufficient material on the portion on which the teeth will be cut to allow not less than the following amounts being machined from surfaces of the finished forging before heat treatment, but leaving 6,5 mm. on all surfaces:—

Large forgings for pinions 150 mm. and over in diameter over the toothed portion when finished—25 mm. on diameters.

Small forgings for pinions under 150 mm. in diameter over the toothed portion when finished—19 mm. on diameters.

Heat Treatment

808 The forgings are to be normalised and tempered or oil-hardened and tempered in accordance with the approved specification.

Number of Tests

809 Tensile and impact tests are to be provided as follows:—

For each pinion forging (or multiple forging) not exceeding 200 mm. in body diameter and 1,22 metres in overall length, a set of longitudinal test pieces is to be taken from one end; where the overall length exceeds 1,22 metres a set is to be taken from both ends.

In addition to the foregoing, a set of transverse test pieces is to be taken from one end of the body portion where the body diameter exceeds 200 mm. and the total length of body portion does not exceed 760 mm.; where this length exceeds 760 mm. a set is to be taken from both ends. In cases where the difference in diameters between the body and journal does not permit the selection of transverse tests, these tests may be taken from the ends of the forgings.

For each pinion sleeve forging (or multiple forging) not exceeding 760 mm. in length, a set of circumferential test pieces is to be taken from one end; where the length exceeds 760 mm. a set is to be taken from both ends.

Batch Testing

810 Where a number of pinion forgings of the same dimensions are forged separately from the same cast and heat treated together in batches, and each forging does not exceed either a length of 1,22 metres or a weight of 150 kg. as forged, the following test procedure may be adopted.

Sufficient material for test purposes shall be left on 5 per cent of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of longitudinal and transverse tests from each of these forgings in accordance with the foregoing and including

sulphur prints may be taken as representative of the batch. The results of these tests are to be confirmed by Brinell tests carried out on all forgings in accordance with 812.

Mechanical Properties

811 The mechanical properties of the forgings, after heat treatment, are to comply with the requirements of Table 1.

Test pieces taken from the circumference of pinion sleeves are to be regarded, for Table 1 requirements, as longitudinal tests where sleeves are hollow-forged and as transverse tests where sleeves are solid-forged and machined hollow (*see* 806).

Tensile tests are to be made on a standard test piece of 50 mm. gauge length and 14 mm. diameter.

Impact tests are to be made on Izod test specimens 10 mm. square with a V notch 2 mm. deep having an included angle of 45 degrees with 0,25 mm. radius at root or a round test specimen 11,5 mm. diameter with a V notch may be used. Alternatively, other 10 mm. square test specimens of the types indicated in Tables 1 and 2 may be adopted.

Hardness Tests

812 Hardness tests are to be taken on all forgings after machining to 6,5 mm. over the finished diameter after heat treatment. The impressions are to be taken at each end of two diameters at right angles in three different positions over each toothed portion of the pinion. The forging will be considered sufficiently uniform if the difference between the highest and lowest value does not exceed 30 in Brinell Numbers, or their equivalent.

Sulphur Prints

813 Sulphur prints are to be taken over the whole of the body portions of the forging in which teeth are to be cut, and in addition, from each end of the body portions to verify that the steel is clean and free from harmful segregations.

TABLE 1—MECHANICAL PROPERTIES FOR PINIONS

MATERIAL—ALLOY STEEL

SPECIFIED MINIMUM TENSILE STRENGTH	MINIMUM YIELD STRESS	MINIMUM PERCENTAGE ELONGATION ON 50 mm.		MINIMUM IMPACT VALUES										HEAT TREATMENT
				LONGITUDINAL					TRANSVERSE					
				kg. metres	kgm/cm.²				kg. metres	kgm/cm.²				
kg. per mm.²	kg. per mm.²	Longitudinal	Transverse	Izod	Charpy Key-Hole	D.V.M.	V.S.M.	Mesnager	Izod	Charpy Key-Hole	D.V.M.	V.S.M.	Mesnager	
63	44	23	16	2,8	4,1	4,6	4,7	5,2	2,1	3,2	3,6	3,6	4,0	Normalised and tempered
63	44	23	16	4,8	6,7	7,8	7,8	8,7	2,8	4,1	4,6	4,7	5,2	Oil-hardened and tempered
71	52	22	15	4,7	6,5	7,6	7,7	8,5	2,5	3,7	4,2	4,2	4,7	
79	60	20	14	4,4	6,2	7,2	7,3	8,0	2,3	3,6	4,0	4,0	4,5	
87	69	18	13	4,1	5,8	6,7	6,8	7,5	2,1	3,2	3,6	3,6	4,0	
94	76	17	12	3,9	5,5	6,3	6,4	7,1	*	*	*	*	*	
102	82	14	10	3,6	5,1	5,9	6,0	6,6	*	*	*	*	*	
110	91	13	9	3,0	4,4	5,1	5,1	5,7	*	*	*	*	*	

*Transverse impact tests are to be made and results recorded.

When considered necessary by the Surveyors, these prints are to be supplemented by magnetic crack detection examinations or other approved tests.

Gear Wheels

814 Wheel rims and solid-forged wheels are to be made from approved steels which in the heat treated conditions have tensile strengths between 47 and 104 kg. per mm.^{2} The specified range of tensile strength is not to exceed 7,9 kg. per mm.^{2} for the carbon steel and 9,4 kg. per mm.^{2} for the alloy steel forgings.

Any of the following type steels will be accepted for this service up to a tensile strength of 71 kg. per mm.^{2} within the range for which they are suitable.

Carbon Steels (0,25% C to 0,55% C)
1% Ni
1% Cr+Mo

Where it is proposed to use other alloy steels of greater tensile strength, or case-hardening steels, full details are to be submitted for consideration.

Manufacture of Forgings

815 Wheels and rims are to be gradually and uniformly forged or rolled from ingots from which the following top and bottom discards have been taken. If rims are made from trepanned ingots sufficient discard shall be made from the top and bottom to ensure soundness in the portion used for forging, and sulphur prints may be taken to demonstrate that this condition has been fulfilled. If the rims or wheels are made from solid ingots the top and bottom discards are to be not less than required in the case of pinions (*see* 805). Rolled bar is not to be used.

Heat Treatment

816 Wheel and rim forgings are to be normalised and tempered or oil-hardened and tempered in accordance with the approved specification.

Number of Tests

817 Tensile and bend tests are to be provided for carbon steels and tensile and impact tests for alloy steels as follows:—

For single wheel or rim forgings greater than 2,44 metres in diameter or 3000 kg. in weight and for multiple forgings, one set of circumferential tests is to be taken from each end of the forging from positions diametrically opposed, provided that in the case of multiple forgings all the portions cut from it are heat treated together. For smaller single wheels or rims a set of circumferential test pieces is to be taken from one end of the forging.

Batch Testing

818 Where a number of wheels or rims of the same dimensions are forged from the same cast and heat treated together in batches, and do not exceed 150 kg. each as forged, the following test procedure may be adopted.

Sufficient material for test purposes shall be left on 5 per cent of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of transverse tests from each of these forgings in accordance with the foregoing may be taken as representative of the batch.

Mechanical Properties

819 The mechanical properties of the forgings, after heat treatment, are to comply with the requirements of Table 2.

The tensile and impact test pieces are to be of the type and size described in 811.

The bend test pieces are to be machined to a rectangular section of 25 mm. wide by 19 mm. thick for carbon steels not exceeding 63 kg. per mm.^{2} tensile strength and 19 mm. wide by 9,5 mm. thick where the tensile strength exceeds 63 kg. per mm.^{2} The edges are to be rounded to a radius of 1,5 mm. in each case. These test pieces are to withstand without fracture, being bent cold through an angle of 180 degrees over a former having a radius not greater than that specified in Table 2. They are to be bent over the thinner section. The bending may be performed either by pressure or by blows.

Hardness Tests

820 Hardness tests are to be made on all wheels and rims as in 812 except that for carbon steels the difference between the highest and lowest value is not to exceed 20 in Brinell Numbers, or their equivalent, for steels of tensile strength not exceeding 63 kg. per mm.^{2} and 30 in Brinell Numbers for steels over 63 kg. per mm.^{2}

Sulphur Prints

821 Sulphur prints are to be taken from the ends of the wheel rim to verify that the steel is clean and free from harmful segregations. Where considered necessary by the Surveyors these prints are to be supplemented by further prints from the cylindrical surfaces and by magnetic crack detection examinations or other approved tests.

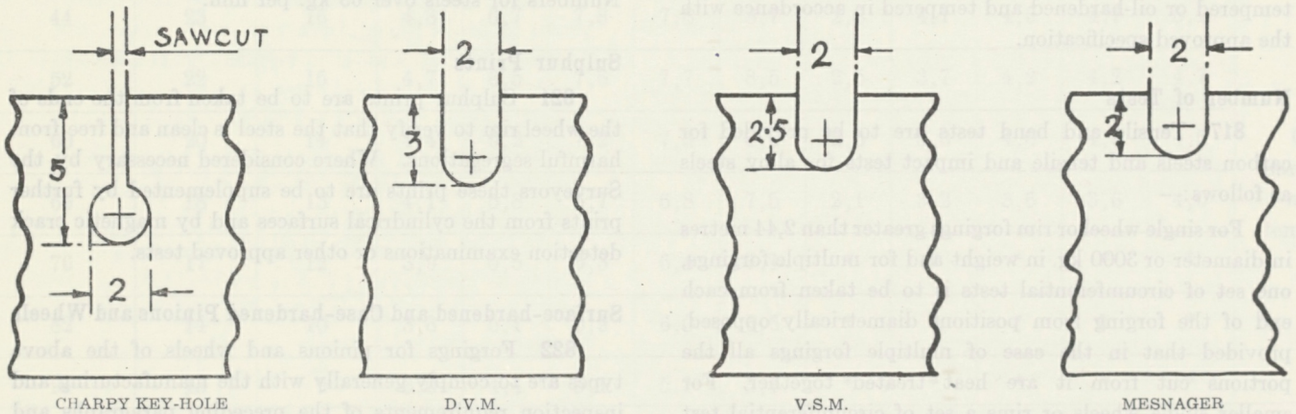
Surface-hardened and Case-hardened Pinions and Wheels

822 Forgings for pinions and wheels of the above types are to comply generally with the manufacturing and inspection requirements of the preceding paragraphs and with the following test requirements.

TABLE 2—MECHANICAL PROPERTIES FOR WHEELS AND RIMS

MATERIAL	HEAT TREATMENT	SPECIFIED MINIMUM TENSILE STRENGTH kg. per mm.²	MINIMUM YIELD STRESS kg. per mm.²	MINIMUM PERCENTAGE ELONGATION ON 50 mm.	BEND TEST RADIUS OF FORMER mm.	MINIMUM IMPACT VALUES				
						kg. metres	kgm/cm.²			
						Izod	Charpy Key-Hole	D.V.M.	V.S.M.	Mesnager
Carbon Steels	Normalised and tempered	47	24	27	6,5	Not applicable				
		55	27	22	9,5					
		63	31	20	16					
		71	35	18	19					
Alloy Steels	Normalised and tempered	63	35	22	Not applicable	*	*	*	*	*
		71	39	20		*	*	*	*	*
		79	43	18		*	*	*	*	*
		87	47	16		*	*	*	*	*
Alloy Steels	Oil-hardened and tempered	63	44	23	Not applicable	4,8	6,7	7,8	7,8	8,7
		71	52	22		4,7	6,5	7,6	7,7	8,5
		79	60	20		4,4	6,2	7,2	7,3	8,0
		87	69	18		4,1	5,8	6,7	6,8	7,5
		94	76	17		3,9	5,5	6,3	6,4	7,1

* Impact tests are to be made and results recorded



CHARPY KEY-HOLE D.V.M. V.S.M. MESNAGER

The dimensions are in millimetres

Tensile and impact tests are to be made to verify that the sub-surface mechanical properties comply with the approved specification. For surface-hardened parts these tests are to be made at the forge in accordance with requirements of 809 and 817: for case-hardened parts the forgings are to be inspected and identified at the forge and the tests made at the engine works or other agreed place after the gears are hardened and finally heat treated. Tests are to be provided as stated in 809 and 817, except that for pinions transverse tests from the body pieces will not be required.

Test blocks for case-hardened parts are to have dimensions such that they will be representative of the forgings and for pinions they are to be not less in diameter than the journals. They are to be blank-carburised and heat treated with the pinion or wheel before being cut up for test purposes. The test pieces are to be cut from the blocks near the surface.

In addition to the aforementioned tensile and impact tests, hardness tests are to be made on the teeth, when hardened and ground, to verify that the surface hardness and sub-surface tensile strength of the teeth comply with the approved specification.

Where it is desired to adopt alternative tests to the foregoing, full details are to be submitted for consideration.

The teeth of all surface- and case-hardened pinions and wheels are to be examined for cracks and other imperfections by magnetic crack-detecting equipment or other approved means.

Section 9

BOILER TUBES AND PRESSURE PIPES

General

901 The following requirements and tolerances are based generally on British practice. Alternative requirements and tolerances of British and other national standard specifications may be accepted where they provide reasonable equivalents to the requirements of this Section.

When the tubes or pipes are of a type or made from an alloy steel for which provision is not made in this Section, they will be required to comply with the terms of an approved specification or with such tests, appropriate to the material, as may be approved.

Requirements for wall thickness, permissible operating temperatures for different steels and service limitations for various types of tubes and pipes are given in the following paragraphs:—

E 508 to E 512—Steel pressure pipes.

J 1201 to J 1208—Smoke tubes and other tubes for cylindrical boilers.

J 1402 & J 1403
J 1615 & J 1616 } Boiler, superheater and downcomer tubes for water tube boilers.

902 The steel is to be made by the open hearth, electric furnace or other approved process, and is to show on analysis not more than 0,05 per cent sulphur or phosphorus.

903 Where the designed operating metal temperature exceeds 400° C., the steel, whether carbon or alloy, is to be of the non-segregated and fully killed type. In order to avoid intergranular penetration by non-ferrous metals, tubes or pipes of alloy steel are not to come into contact with such metals or their compounds during manufacture.

A certificate giving the chemical analysis of the steel for each cast is to be provided for all tubes and pipes.

904 Cold drawn carbon steel tubes or pipes are to be annealed or normalised after drawing. Low alloy molybdenum and chromium molybdenum steel tubes or pipes are to be annealed or normalised; other alloy steel tubes or pipes are to be given a heat treatment suitable for the materials concerned.

905 All tubes and pipes are to be smooth and practically concentric throughout their length and are to be examined externally and internally and be free from defects. Ends are to be ground where necessary to facilitate examination.

Boiler Tubes. (Smoke tubes, water tubes and superheater tubes.)

906 Tubes for water tube boilers and superheaters are to be seamless unless otherwise specially approved; those under 38 mm. external diameter are to be cold drawn.

907 Tolerances on thickness and diameter of straight tubes are not to exceed those given in Table 1.

908 Every tube is to be tested, at the makers' works, by hydraulic pressure to the requirements of Table 2.

The makers' certificate of hydraulic test may be accepted.

TABLE 1—TOLERANCES

TYPE OF TUBE	OUTSIDE DIAMETER	PERMISSIBLE TOLERANCES	
		THICKNESS	DIAMETER
Hot Finished	Up to 63 mm.	+17½% − 7½%	+0,4 mm. −0,8 mm.
	Over 63 mm. and up to 115 mm.	+15% − 5%	+1% −1%
Cold Drawn	All sizes	+10% − 5%	+0 −1%

TABLE—2 HYDRAULIC TEST PRESSURES

WORKING PRESSURE KG. PER SQUARE CM.	HYDRAULIC TEST PRESSURE KG. PER SQUARE CM.
Up to and including 35 ...	70
Over 35 up to and including 70	2 × working pressure
Over 70	Working pressure + 70

909 Tubes of the same diameter, thickness and material are to be presented for mechanical testing in batches of 100 tubes. Two tubes are to be selected indiscriminately from at least two of the batches and one tube from each remaining batch. The selected tubes are to be subjected to tensile, flattening and expanding tests, as detailed in the following paragraphs.

910 Tensile test pieces may be strips cut from the tubes or lengths of full section tube. In the case of hot finished tubes where the tube ends only have been annealed the test pieces are to be taken from the un-annealed portion of the tube. The mechanical properties are to comply with the requirements of Table 3.

911 Expanding tests are to be made on both ends of all selected tubes using a drift expander having a total included angle of from 40°–60°. The tube ends are to withstand when cold and without signs of cracking the increases in diameter given in Table 4.

912 Flattening tests are to be made on one selected tube from each batch. This tube is to withstand being flattened when cold and without cracking, to the extent given in Table 4, at three different positions; one position is to be near the middle of the length and all are to be in different planes.

913 Should one of the selected tubes fail to comply with any one or more of the tests specified in 910 to 912, two further tests of the same kind are to be made on two additional tubes selected from the same batch. If failure again occurs the batch of tubes is to be rejected as unsatisfactory.

Pressure Pipes

914 Pipes may be seamless, or of other approved type as required in E 509 to E 511, according to the service for which they are intended.

915 Tolerances on thickness and diameter of straight pipes are not to exceed those given in Table 5.

916 Every pipe, while straight and with plain ends, is to be hydraulically tested at the makers' works to the pressure derived from the formula given below or to 70 kg. per square cm. whichever is less.

For Seamless Carbon and Alloy Steels

$$\text{Test Pressure} = {}^{t}/_{D} \times S \times 54$$

Where t = nominal thickness, in millimetres.
D = nominal outside diameter, in millimetres.
S = minimum tensile breaking strength, in kg. per square mm.

The makers' certificate of hydraulic test may be accepted.

917 Mechanical tests are to be taken in the following proportions from pipes of the same diameter and thickness and from the same cast.

Up to and including 115 mm. O.D....1 in 40 or part thereof
Over 115 mm. and up to 153 mm. O.D....1 in 10 or part thereof
Over 153 mm. O.D. ... ...1 in 5 or part thereof

The mechanical tests required are a tensile test and either a flattening or bend test. Flattening tests are to be made on pipes up to 115 mm. O.D. and bend tests on pipes over 115 mm. O.D.

TABLE 3—MECHANICAL PROPERTIES

TYPE OF STEEL	TYPE OF TEST PIECE	RANGE OF TENSILE BREAKING STRENGTH, KG. PER SQUARE MM.	MINIMUM ELONGATION, PER CENT			
			Less than 6,4 mm. thick		6,4 mm. thick and over	
			on 200 mm.	on 50 mm.	on 200 mm.	on 50 mm.
Carbon	Strip	32 to 44	18	28	20	30
	Full section		23	—	25	—
½% Mo.	Strip	40 to 55	17	23	19	25
	Full section		21	—	23	—
1% Cr. ½% Mo.	Strip	43 to 58	16	22	18	24
	Full section		20	—	22	—

TABLE 4—EXPANDING AND FLATTENING TESTS

THICKNESS OF TUBE MILLIMETRES.	EXPANDING TEST		FLATTENING TEST		
	Increase in O.D. per cent		Distance apart of inner surfaces		
			Carbon Steel		Alloy Steel
	Carbon Steel	Alloy Steel	Cold Drawn	Hot Finished	
Up to 3,25	15	12½	Touching	3 times the thickness	
Over 3,25 and up to 4,9		9½	2 times the thickness		
Over 4,9 and up to 6,4	12	6½			
Over 6,4	9½				

TABLE 5—TOLERANCES FOR SEAMLESS PIPES

TYPE OF PIPE	PERMISSIBLE TOLERANCES					
	THICKNESS		OUTSIDE DIAMETER		BORE	
	$t/D \leq 3\%$	$t/D > 3\%$	up to 48,5 mm. O.D.	Over 48,5 mm. O.D.	Under 153 mm. bore	153 mm. bore and over
Hot Finished	+15% −15%	+12½% −12½%	+0,4 mm. −0,8 mm.	+1% −1%	—	—
Cold Drawn	+10% −10%		—	—	+1% −1%	+0,8 mm. −1,6 mm.

TABLE 6—MECHANICAL PROPERTIES

TYPE OF STEEL	TYPE OF TEST PIECE	RANGE OF TENSILE BREAKING STRENGTH, KG. PER SQUARE MM.	MINIMUM ELONGATION, PER CENT			
			Less than 6,4 mm. thick		6,4 mm. thick and over	
			on 200 mm.	on 50 mm.	on 200 mm.	on 50 mm.
Carbon	Strip	36 to 47	18	28	20	30
	Full section		23	—	25	—
½% Mo.	Strip	40 to 55	17	23	19	25
	Full section		21	—	23	—
1% Cr. ½% Mo.	Strip	43 to 58	16	22	18	24
	Full section		20	—	22	—

918 Tensile test pieces may be strips cut from the pipes or lengths of full section pipe. The mechanical properties are to comply with the requirements of Table 6.

919 A flattening test, on pipes up to 115 mm. O.D., is to be made on a ring not less than 38 mm. long, cut from one end of each selected pipe. This ring is to withstand being flattened, when cold and without cracking, until the distance apart of the inner surfaces of the pipe is 4 times its thickness or ⅔ of the bore, whichever is less.

920 A bend test on pipes over 115 mm. O.D., is to be made on a strip not less than 38 mm. wide cut circumferentially from one end of each selected pipe. This strip is to withstand being bent double in the direction of original curvature, when cold and without cracking, over a round bar or former of diameter as follows:—

Up to 9,5 mm. thickness... 3 times the pipe thickness

Over 9,5 mm. thickness.... 4 times the pipe thickness or ⅔ of the bore whichever is less.

921 Should a pipe selected for testing fail to comply with any one or more of the tests specified in 918 to 920 two further tests of the same kind are to be made from another pipe from the same batch. If failure again occurs the batch of pipes is to be rejected as unsatisfactory.

Section 10

BRONZE PROPELLERS AND PROPELLER BLADES

General

1001 The requirements of this section are applicable to propeller castings of the following non-ferrous materials:—

(a) Manganese bronze or high tensile brass with a minimum tensile strength of 44 kg. per mm.^{2}

(b) High tensile aluminium bronzes with a minimum tensile strength of 63 kg. per mm.^{2}

Particulars of chemical composition and mechanical properties of proprietary alloys are to be submitted for information.

1002 Where it is proposed to use other non-ferrous materials or different grades of type (a) and (b) alloys, full particulars are to be submitted for consideration.

1003 Castings are to be clean and free from harmful defects and are to be tested and inspected at the makers' works. In the event of any casting proving defective in the course of subsequent machining such casting may be rejected notwithstanding any previous certification of satisfactory test.

Provision of Test Samples

1004 Test samples, sufficient for the preparation of at least three test pieces, are to be provided for each casting. The test samples are to be of approved form and may be separately-cast or integral with the casting.

1005 Separately-cast test samples:— These may be adopted at works where Surveyors are in frequent attendance. The procedure for identifying the test samples and the propeller casting is to be approved by the Surveyors who in cases of doubt may require that check analyses of sample and casting be made.

The samples are to be separately cast at the same time and from the same metal as the casting which they represent, and are to be poured into moulds of the same material as that used for the casting. Where a casting is made from more than one ladle test samples are to be provided for each ladle.

1006 Integral test samples:— These are to be provided as blocks cast on the surfaces of the casting. Samples gated from the casting are not acceptable.

NOTE.—With the object of obtaining sound test blocks and of permitting free contraction of the propeller casting, it is preferable that the test blocks be arranged axially on the hub instead of on the blades at mid-radii.

Mechanical Properties

1007 Test pieces are to be 14 mm. diameter with a gauge length of 50 mm. or of other similar standard. At least one tensile test is to be made for each casting and for each ladle if 1005 is applicable. The test results are to comply with the requirements of the following table or of a specification specially approved.

If the first test piece fails to meet requirements, then the two remaining test pieces are to be broken; if these also fail the casting is to be rejected.

Material	Minimum Tensile Strength kg. per mm.^{2}		Minimum Elongation per cent on 50 mm. gauge length
	Integral test piece	Separately-cast test piece	
(a) Manganese Bronze	44	47	20
(b) Aluminium Bronze	63	66	15

NOTE.—The values in the table are applicable to test pieces and are not necessarily obtainable from all parts of the castings. In general it can be expected that the mechanical properties of a propeller, especially in the thick root sections of the blades, will be inferior to those of the test piece.

Section 11

ANCHORS

Process of Manufacture

1101 Anchors are to be made of forged ingot steel or cast steel. Forged steel anchors are to be manufactured in accordance with the relevant requirements of P 6. The carbon content of the steel is not to exceed 0,25 per cent, other elements in the steel being restricted in accordance with P 604. When the weight of the forging exceeds 3000 kg., it is to be heat treated by normalising. The tensile strength of forged carbon steel anchors is not to exceed 52 kg. per mm.^{2} The manufacturing process of cast steel anchors is to comply with the relevant requirements of P 5. Forged and cast steel anchor heads and cast steel shanks are to be subjected to the test requirements of P 6 and P 5 respectively. All steel castings are to be subjected to hammering tests as detailed in P 515 but percussive tests are not required.

Where, however, more than one anchor head is poured from a charge one tensile and one bend test per charge will be accepted, provided all anchor heads from the charge are heat treated at the same time and under the same conditions. If the weight of a charge exceeds 3000 kg. and more than one anchor is poured from the charge, a further tensile and bend test should be taken.

1102 Each important part of an anchor is to be plainly marked by the maker with the words "forged ingot steel" or "heat treated cast steel" as the case may be (or simply "forged steel" or "cast steel").

1103 Steel anchor shackles are to be made of forged ingot steel or cast steel as specified in 1101, but need not be submitted to the test requirements of P 5 and P 6.

Proof Tests of Anchors

1104 Anchors weighing more than 76 kg., inclusive of stock, are to be tested at a proving establishment recognised by the Committee (*see* D 3321). When the (United Kingdom) Anchors and Chain Cables Act applies* the anchors are to be tested at a Licensed Proving House in the United Kingdom.

*NOTE.—The Anchors and Chain Cables Act, 1899, applies to anchors bought or sold in the United Kingdom for use on a British ship.

1105 The test load is to be as given in Table 1A, or Table 1B if the Anchors and Chain Cables Act applies.

The weight to be used in the Table is:—

(a) for stockless anchors—the total weight of the anchor,

(b) for stocked anchors—the weight of the anchor excluding the stock,

(c) for high holding power anchors (*see* D 3312)—a nominal weight equal to one-and-one-third times the actual total weight of the anchor.

TABLE 1A—PROOF TESTS FOR ANCHORS

WEIGHT OF ANCHOR (*See* P 1105)	PROOF TEST LOAD	WEIGHT OF ANCHOR (*See* P 1105)	PROOF TEST LOAD	WEIGHT OF ANCHOR (*See* P 1105)	PROOF TEST LOAD	WEIGHT OF ANCHOR (*See* P 1105)	PROOF TEST LOAD	WEIGHT OF ANCHOR (*See* P 1105)	PROOF TEST LOAD	WEIGHT OF ANCHOR (*See* P 1105)	PROOF TEST LOAD
Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.
50	2370	450	10900	1600	29800	3900	57800	6200	76200	10000	97100
55	2570	475	11400	1700	31300	4000	58800	6300	76900	10500	99300
60	2760	500	11800	1800	32700	4100	59800	6400	77500	11000	101500
65	2950	550	12700	1900	34200	4200	60700	6500	78200	11500	103600
70	3130	600	13500	2000	35600	4300	61600	6600	78800	12000	105700
75	3300	650	14300	2100	36900	4400	62500	6700	79400	12500	107800
80	3460	700	15200	2200	38300	4500	63400	6800	80100	13000	109900
90	3700	750	16100	2300	39600	4600	64300	6900	80700	13500	111900
100	3990	800	16900	2400	40900	4700	65100	7000	81300	14000	113900
120	4520	850	17800	2500	42200	4800	65800	7200	82600	14500	115900
140	5000	900	18600	2600	43500	4900	66600	7400	83800	15000	117700
160	5430	950	19500	2700	44700	5000	67400	7600	85000	15500	119500
180	5850	1000	20300	2800	45900	5100	68200	7800	86100	16000	120900
200	6250	1050	21200	2900	47100	5200	69000	8000	87000	16500	122200
225	6810	1100	22000	3000	48300	5300	69800	8200	88100	17000	123500
250	7180	1150	22800	3100	49400	5400	70500	8400	89200	17500	124700
275	7640	1200	23600	3200	50500	5500	71300	8600	90300	18000	125900
300	8110	1250	24400	3300	51600	5600	72000	8800	91400	18500	127000
325	8580	1300	25200	3400	52700	5700	72700	9000	92400	19000	128000
350	9050	1350	26000	3500	53800	5800	73500	9200	93400	19500	129000
375	9520	1400	26700	3600	54800	5900	74200	9400	94400	20000	130000
400	9980	1450	27500	3700	55800	6000	74900	9600	95300	21000	131000
425	10500	1500	28300	3800	56800	6100	75500	9800	96200	22000	132000

Table 1B—Proof Tests for Anchors

(Subject to Anchors and Chain Cables Act.)

Weight of Anchor (*See* P 1105)	Proof Test Load	Weight of Anchor (*See* P 1105)	Proof Test Load	Weight of Anchor (*See* P 1105)	Proof Test Load	Weight of Anchor (*See* P 1105)	Proof Test Load	Weight of Anchor (*See* P 1105)	Proof Test Load	Weight of Anchor (*See* P 1105)	Proof Test Load
Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.
75	4000	540	12750	1200	24000	3700	56050	6200	76600	8700	91000
80	4100	560	13150	1300	25700	3800	57050	6300	77250	8800	91500
90	4300	580	13550	1400	27250	3900	58050	6400	77850	8900	92000
100	4550	600	13950	1500	28750	4000	58950	6500	78500	9000	92500
120	4950	620	14300	1600	30250	4100	59800	6600	79100	9100	93000
140	5350	640	14650	1700	31750	4200	60800	6700	79750	9200	93500
160	5700	660	15000	1800	33250	4300	61800	6800	80350	9300	94000
180	6100	680	15300	1900	34600	4400	62750	6900	81000	9400	94500
200	6450	700	15700	2000	35950	4500	63550	7000	81600	9500	95000
220	6850	720	16050	2100	37300	4600	64500	7100	82200	9600	95500
240	7250	740	16400	2200	38750	4700	65300	7200	82850	9700	96000
260	7600	760	16750	2300	40050	4800	66250	7300	83500	9800	96500
280	7950	780	17100	2400	41300	4900	67000	7400	84100	9900	97000
300	8300	800	17450	2500	42550	5000	67750	7500	84750	10000	97500
320	8700	820	17800	2600	43800	5100	68500	7600	85350	10500	99800
340	9100	840	18150	2700	45050	5200	69250	7700	85900	11000	101950
360	9500	860	18500	2800	46200	5300	70000	7800	86450	11500	103950
380	9850	880	18800	2900	47450	5400	70750	7900	86950	12000	105900
400	10200	900	19100	3000	48550	5500	71500	8000	87450	12500	107900
420	10600	920	19400	3100	49700	5600	72250	8100	88000	13000	109900
440	11000	940	19750	3200	50800	5700	73000	8200	88500	13500	111900
460	11400	960	20100	3300	51800	5800	73750	8300	89000	14000	113900
480	11700	980	20450	3400	52800	5900	74500	8400	89500	14500	115900
500	12050	1000	20800	3500	54050	6000	75250	8500	90000	15000	117900
520	12400	1100	22550	3600	55050	6100	76000	8600	90500	15500	119900

The weight given in the above Table is either for stockless anchors or for stocked anchors without the stock.
For intermediate weights the test may be obtained by interpolation.
For high holding power anchors the weight to be used in the Table is to be that of the actual anchor increased by one-third.

Section 12 Not allocated at present

Section 13

CHAIN CABLES AND STEERING CHAINS

NOTE.—For list of approved manufacturers *see* Appendix to this Chapter.

Scope

1301 Provision is made for the testing of bar material intended for the manufacture of welded chain, material tests for drop forged and cast links and the testing of completed chain, attachment links and shackles. Chain cables or steering gear chains may be of any one of the following grades:—

Designation	Grade	Method of Manufacture	Tensile Range Kg./mm.^{2}
Mild Steel	U 1(a)	Flash-butt welded	31–41
	U 1(b)	,, ,, ,,	41–50
Special Quality	U 2(a)	Flash-butt welded or Drop Forged	50–65
	U 2(b)	Cast Steel	50 min.
Extra Special Quality ...	U 3	Flash-butt welded or Drop Forged	70 min.

1302 In addition to the above, chain cable may be fire welded of wrought iron (Grade 1(a)) or of mild steel (Grade 1(b)) having a tensile strength of 31–41 kg. per mm.^{2}.

These types are to comply with the requirements given in this Section for Grade U 1(a) not heat treated but the method of manufacture does not require to be approved.

Method of Manufacture

1303 The steel used for the manufacture of chain cable is to be made in accordance with P 101. Rimming steel is not acceptable.

The links may be made by the flash-butt or other approved welding process or they may be steel castings or drop forgings. The method of manufacture and the chemical composition are to be approved and the requisite preliminary tests carried out. Approval tests for higher grades cover lower grades (up to the same diameter) provided the method of manufacture and heat treatment are generally the same.

Chemical Composition

1304 The chemical composition is to comply with the manufacturer's approved specification and is to be determined in accordance with P 216.

Heat Treatment

1305 (a) Bar material intended for the manufacture of chain may be supplied in the "as rolled" or heat treated condition in accordance with the requirements of the chain maker.

(b) HEAT TREATMENT OF COMPLETED CHAIN. Grade U 1 chain cable may either be supplied in the "as welded" condition or may be normalised. If supplied in the "as welded" condition additional breaking tests will be required as detailed in Table 2.

Grade U 2 cable is to be normalised or normalised and tempered but Grade U 2(b) cast steel cable may at option of the manufacturer be hardened by quenching and tempered.

Grade U 3 cable is either to be normalised and tempered or hardened by quenching and tempered.

In all cases heat treatment is to be carried out prior to the proof loading and breaking tests.

1306 For certain types of drop forged cable the requirements of 1305, and the procedure for material tests, will be specially considered.

Test Material and Test Pieces

1307 (a) For Grades U 1 and U 2(a) the bar material may be tested either in the "as rolled" condition or after heat treatment in full size and in a manner simulating the heat treatment applied to the finished cable. For Grade U 3 the test material is to be heat treated in full size and in a manner simulating the treatment applied to the finished chain.

Test material representative of cast or drop forged links is to be heat treated along with and in the same manner as the completed cable (*see also* 1306).

(b) For material tests one set of tests as required by Table 1 is to be taken from every 10 tonnes or part of 10 tonnes of each dimension from the same cast where the bar diameter does not exceed 60 mm. Where the diameter exceeds 60 mm. but does not exceed 80 mm. they are to be taken from every 15 tonnes and for diameters exceeding 80 mm. from every 25 tonnes.

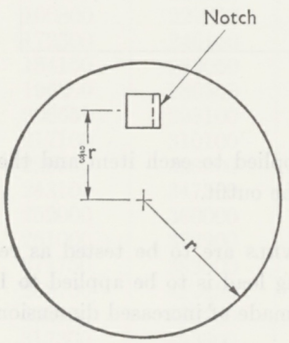
From completed chain, 3-link samples are to be selected by the Surveyor for the breaking tests specified in 1310(b). In addition, for grade U 3, extra links are required for mechanical tests specified in 1310(c).

(c) Tensile test pieces may be either the full section "as rolled" or of the round proportional type provided the cross-sectional area is not less than 161 mm.^{2}. For machined test pieces the diameter of the reduced portion and the position of the test piece relative to the bar cross-section are to be selected so that the test piece is representative of the average properties of the bar.

The gauge length is generally to be five times the diameter of the test portion. For other gauge lengths the equivalent elongations are to be determined in accordance with P 205(b).

Bend test pieces may be either the full section as rolled, or may be machined to 25 mm. diameter, or rectangular cross section 25×19 mm.

Impact test pieces are to be of the Charpy V-notch type in accordance with P 207. They are to be cut as shown in the sketch:—



(d) Additional tests before rejection may be taken in accordance with P 213.

Mechanical Properties

1308 In all cases the results of tensile bend and impact tests are to comply with Table 1.

Inspection and Testing of Completed Chain

1309 (a) All chain cable and steering chains are to be tested at a proving establishment recognised by the Committee (*see* D 3320). When the (United Kingdom) Anchors & Chain Cables Act* applies the cables are to be tested at a licensed proving house in the United Kingdom.

*The Anchor & Chain Cables Act, 1899, applies to chain cables bought or sold in the United Kingdom for use on a British ship.

The tests detailed in 1310 are to be applied.

Each length of chain is to be carefully examined after proof loading and is to be free from significant defects.

1310 (a) Proof Loading Test. Each length of chain cable is to be subjected to a proof loading test in an approved testing machine and is to withstand the load given in Table 3A for the appropriate grade and size of cable.

(b) Breaking Test. Breaking test specimens are to be taken as required by Table 2 and are to withstand the load given in Table 3A for the appropriate grade and size of cable. The specimen shall be considered to have passed this test if it has shown no sign of fracture after application of the required load.

When the (United Kingdom) Anchors & Chain Cables Act applies one 3-link sample is to be taken from every 27,5 metres (or less) length and the breaking load is to be as given in Table 3B.

(c) Mechanical Tests. For Grade U 3 chain cable, one set of tests (1 tensile and 3 impact test pieces) is to be taken from every second 27,5 metres length of cable. For this purpose every second length is to be supplied with 1 or 2 extra links. Test pieces are to be taken clear of the weld.

The results of these tests are to comply with the requirements given in Table 1.

1311 Shackles. End and joining shackles are to be subjected to the breaking and proof loads appropriate to the grade of cable for which they are intended. The breaking load shall be applied to at least one shackle out of 25 (1 in 50 for lugless shackles).

Drop forged, cast steel and lugless shackles are to be manufactured to an agreed specification and tensile and

TABLE 1

Designation	Method of Manufacture	Tensile Range Kg./mm.²	Elongation (on 5D) Minimum %	Impact	Maximum Diameter of Former
Mild Steel					
Grade U 1(a)	Flash-butt welded	31–41	30	—	1T
U 1(b)	,, ,, ,,	41–50	25	—	2T
Special Quality					
Grade U 2(a)	Flash-butt welded or drop forged	50–65	22	—	3T
U 2(b)	Cast Steel	50 min.	22	—	3T
Extra Special Quality					
Grade U 3	Flash-butt welded or drop forged	70 min.	17	6 kg.m. at 0° C.	—

Notes (1) T is equal to the diameter or thickness of the bend test piece.
(2) For Grade U 3 cable, minimum reduction of area = 50 %.
(3) The impact value is the average value from three tests.

Table 2—Number of Breaking Tests

Designation	Method of Manufacture	Number of Breaking Test Specimens
Grade U 1 Grade U 2(a) Grade U 3	Flash-butt welded, or drop forged, and heat treated	One from every four lengths of 27,5 metres or less
Grade U 1	Flash-butt welded but not heat treated	One from each length of 27,5 metres or less
Grade U 2(b)	Cast and heat treated	One per heat treatment batch with a minimum of one from every four lengths of 27,5 metres or less

impact or bend tests taken. The test samples are to be subjected to the same heat treatment as the shackles.

1312 Attachment Links, Adaptor Pieces, Etc., are to be subjected to the breaking and proof loads appropriate to the grade of cable for which they are intended. The breaking load is to be applied to 1 item out of every 25 (or less) and this item is to be destroyed and not used as part of an outfit. Where, however, the items are of increased dimensions, and have been specially approved, the breaking load may be applied to each item and the item so tested included with the outfit.

1313 Swivels are to be tested as required by 1312 but the breaking load is to be applied to 1 out of every 7 (or less) unless made of increased dimensions.

1314 All items subjected to the breaking load are to be destroyed and not used in the outfit except as specifically permitted by 1312 for items of increased dimensions.

TABLE 3A—STUD LINK CHAIN CABLE

Chain Diameter	GRADE						Minimum weight per length of 27,5 metres	
	U 1		U 2		U 3			
	Proof Load	Breaking Load	Proof Load	Breaking Load	Proof Load	Breaking Load	With Dee Shackle	With Lugless Shackle
mm.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.
12,5	4700	6720	6720	9400	9400	13450	107	105
14	5880	8400	8400	11770	11770	16800	130	127
16	7660	10940	10940	15310	15310	21950	160	157
17,5	9130	13040	13040	18260	18260	26100	190	186
19	10740	15340	15340	21470	21470	30700	220	216
20,5	12470	17800	17800	24930	24930	35600	252	248
22	14310	20440	20440	28620	28620	40900	290	286
24	16970	24240	24240	33930	33930	48500	350	345
26	19840	28340	28340	39670	39670	56700	410	405
28	22920	32740	32740	45840	45840	65500	480	475
30	26200	37450	37450	52400	52400	74900	550	545
32	29700	42450	42450	59400	59400	84850	620	615
34	33400	47700	47700	66800	66800	95450	700	690
36	37300	53300	53300	74600	74600	106600	785	775
38	41400	59150	59150	82800	82800	118300	875	860
40	45700	65280	65280	91400	91400	130550	965	950
42	50200	71700	71700	100350	100350	143400	1055	1040
44	54850	78350	78350	109700	109700	156750	1150	1130
46	59700	85300	85300	119450	119450	170650	1260	1240
48	64750	92550	92550	129550	129550	185050	1370	1345
50	70000	100000	100000	140000	140000	200000	1485	1455
52	75400	107750	107750	150800	150800	215450	1605	1575
54	81000	115700	115700	162000	162000	231400	1725	1690
56	86750	123950	123950	173500	173500	247850	1850	1810
58	92700	132400	132400	185350	185350	264800	1985	1945
60	98800	141100	141100	197550	197550	282250	2125	2075
62	105050	150050	150050	210100	210100	300150	2275	2220
64	111500	159250	159250	222950	222950	318500	2430	2370
66	118050	168650	168650	236150	236150	337350	2590	2525
68	124800	178300	178300	249600	249600	356600	2755	2685
70	131700	188150	188150	263400	263400	376300	2925	2850
73	142350	203350	203350	284700	284700	406700	3185	3100
76	153300	219050	219050	306650	306650	438050	3460	3360
78	160800	229750	229750	321600	321600	459450	3640	3535
81	172300	246150	246150	344650	344650	492350	3940	3820
84	184150	263050	263050	368250	368250	526100	4240	4105
87	196250	280350	280350	392500	392500	560700	4555	4405
90	208650	298100	298100	417300	417300	596150	4870	4705
92	217100	310100	310100	434150	434150	620250	5080	4905
95	229950	328500	328500	459900	459900	657000	5405	5210
98	243100	347300	347300	486200	486200	694550	5740	5530
100	252000	360000	360000	504000	504000	720000	5970	5745
102	261000	372900	372900	522050	522050	745760	6210	5970
105	274750	392500	392500	549500	549500	784980	6580	6320
108	288700	412450	412450	577400	577400	824850	6975	6695
111	302900	432700	432700	605800	605800	865450	7380	7080
114	317300	453300	453300	634600	634600	906600	7795	7475
117	331950	474200	474200	663850	663850	948350	8220	7870
120	346750	495350	495350	693500	693500	990700	8650	8270

Table 3B (Inch Units)—Stud Link Chain Cable

(Subject to Anchors and Chain Cables Act)

Diameter	Grade U 1		Grade U 2		Minimum weight per length of 15 fathoms	
	Proof Load	Breaking Load	Proof Load	Breaking Load	With Dee Shackle	With Lugless Shackle
Inches	Tons	Tons	Tons	Tons	Cwts.	Cwts.
7/16	3·40	5·10	4·80	7·10	1¾	1 11/16
½	4·50	6·75	6·30	9·50	2⅛	2 1/16
9/16	5·65	8·40	7·90	11·80	2⅝	2 9/16
⅝	7·00	10·50	9·80	14·70	3¼	3 3/16
11/16	8·50	12·75	11·90	17·90	3⅞	3 9/16
¾	10·15	15·15	14·20	21·20	4⅜	4 5/16
13/16	11·90	17·80	16·60	24·90	5⅛	5 1/16
⅞	13·75	20·65	19·30	28·90	5⅞	5¾
15/16	15·80	23·70	22·10	33·20	6¾	6⅝
1	18·00	27·00	25·20	37·80	7⅞	7½
1 1/16	20·30	30·40	28·40	42·60	8⅛	8½
1⅛	22·75	34·15	31·90	47·80	9¾	9⅝
1 3/16	25·40	38·00	35·50	53·20	10⅞	10¾
1¼	28·15	42·15	39·40	59·00	12	11⅞
1 5/16	31·00	46·50	43·40	65·10	13¼	13 1/16
1⅜	34·00	51·00	47·60	71·40	14½	14 5/16
1 7/16	37·15	55·65	52·00	77·90	15⅞	15 11/16
1½	40·50	58·70	56·70	82·20	17¼	17
1 9/16	43·90	61·40	61·40	86·00	18¾	18½
1⅝	47·50	66·50	66·50	93·10	20	19⅝
1 11/16	51·25	71·75	71·75	100·50	21½	21⅛
1¾	55·15	77·15	77·15	108·00	23⅛	22¾
1 13/16	59·15	82·75	82·75	115·90	24⅞	24½
1⅞	63·25	88·50	88·50	123·90	26⅝	26⅛
1 15/16	67·50	94·50	94·50	132·30	28⅜	27⅞
2	72·00	100·80	100·80	141·10	30	29⅝
2 1/16	76·50	107·10	107·10	149·90	31⅞	31¼
2⅛	81·25	113·75	113·75	159·30	33¾	33
2 3/16	86·15	120·50	120·50	168·70	35⅞	35⅛
2¼	91·15	127·50	127·50	178·50	37⅞	37
2 5/16	96·25	134·75	134·75	188·75	40	39⅛
2⅜	101·50	142·10	142·10	198·90	42¼	41¼
2 7/16	106·90	149·65	149·65	209·50	44½	43⅜

(*See Continuation*)

TABLE 3B (INCH UNITS)—STUD LINK CHAIN CABLE (*Continued*)

(Subject to Anchors and Chain Cables Act)

Diameter	GRADE				Minimum weight per length of 15 fathoms	
	U 1		U 2			
	Proof Load	Breaking Load	Proof Load	Breaking Load	With Dee Shackle	With Lugless Shackle
Inches	Tons	Tons	Tons	Tons	Cwts.	Cwts.
2½	112·50	157·50	157·50	220·50	47	45⅞
2 9/16	116·70	163·40	163·40	228·70	49½	48¼
2⅝	120·90	169·25	169·25	237·00	52	50⅝
2 11/16	125·10	175·15	175·15	245·20	54½	53⅛
2¾	129·30	181·00	181·00	253·40	57⅛	55⅝
2 13/16	133·40	186·75	186·75	261·50	59⅞	58¼
2⅞	137·60	192·65	192·65	269·70	62⅝	60⅞
2 15/16	141·70	198·40	198·40	277·70	65½	63⅝
3	145·80	204·10	204·10	285·70	68⅜	66⅜
3 1/16	149·80	209·70	209·70	293·60	71¼	69⅛
3⅛	153·75	215·25	215·25	301·40	74¼	72
3 3/16	157·70	220·75	220·75	309·10	77⅜	75
3¼	161·60	226·20	226·20	316·70	80⅜	77⅞
3 5/16	165·40	231·50	231·50	324·10	83⅛	81
3⅜	169·15	236·75	236·75	331·50	86⅞	84⅛
3 7/16	172·75	241·80	241·80	338·50	90⅛	87⅛
3½	176·40	246·90	246·90	345·70	93½	90⅜
3 9/16	179·90	251·80	251·80	352·50	96¾	93½
3⅝	183·25	256·50	256·50	359·00	100	96½
3 11/16	186·50	261·10	261·10	365·50	103⅛	99¾
3¾	189·80	265·70	265·70	372·00	106⅛	102¾
3 13/16	192·90	270·00	270·00	378·00	109⅞	105⅞
3⅞	195·90	274·25	274·25	384·00	113¼	109
3 15/16	198·80	278·30	278·30	389·65	116¾	112¼
4	201·60	282·20	282·20	395·10	120⅛	116
4 1/16	204·20	285·90	285·90	400·25	124⅛	119¾
4⅛	206·70	289·40	289·40	405·15	128⅛	123½
4 3/16	—	—	292·60	409·65	132¾	127½
4¼	—	—	295·80	414·15	136⅞	131⅜
4 5/16	—	—	298·70	418·20	141⅛	135⅜
4⅜	—	—	301·40	422·00	145⅜	139⅜
4 7/16	—	—	303·80	425·35	149¾	143½
4½	—	—	306·15	428·60	154⅛	147⅜

TABLE 4—SHORT LINK CHAIN CABLE

Diameter	GRADE				Minimum weight per length of 27,5 metres	
	U 1		U 2			
	Proof Load	Breaking Load	Proof Load	Breaking Load	Forged	Electric Welded
mm.	kg.	kg.	kg.	kg.	kg.	kg.
11	2250	4500	3150	6300	100	60
12	2700	5400	3800	7600	115	75
13	3200	6400	4500	9000	130	95
14	3650	7300	5200	10400	145	115
15	4200	8400	5950	11900	160	135
16	4800	9600	6750	13500	175	155
17	5450	10900	7650	15300	195	175
18	6100	12200	8600	17200	215	195
19	6800	13600	9550	19100	240	215
20	7550	15100	10600	21200	265	235
21	8300	16600	11700	23400	290	260
22	9100	18200	12800	25600	315	285
23	9950	19900	14000	28000	345	310
24	10900	21700	15300	30500	375	340
25	11800	23600	16600	33100	405	370
26	12800	25500	17900	35800	440	400
27	13700	27400	19300	38500	475	435
28	14800	29500	20800	41500	510	470
29	15900	31700	22300	44500	545	505
30	17000	34000	23900	47700	580	540
31	18200	36300	25500	50900	620	575
32	19400	38700	27100	54200	655	615
33	20600	41100	28900	57700	695	650
34	21800	43600	30600	61200	740	690
35	23100	46200	32400	64800	785	730
36	24500	48900	34300	68600	830	770
37	25900	51700	36300	72500	875	810
38	27300	54600	38200	79400	920	855
39	28800	57500	40300	80500	970	905
40	30200	60400	42300	84600	1020	955
41	31700	63400	44500	89000	1070	1005
42	33300	66600	46700	93400	1125	1055
43	34900	69800	49000	97900	1180	1105
44	36600	73200	51300	102000	1240	1155
45	38300	76500	53600	107000	1300	1205
46	39900	79900	56000	112000	1360	1260
47	41700	83400	58200	117000	1425	1315
48	43500	87000	61000	122000	1490	1370
49	45400	90700	63500	127000	1555	1430
50	47300	94500	66200	132000	1625	1490
51	49200	98300	68800	138000	1695	1555

Section 14

STEEL WIRE ROPES FOR STANDING RIGGING, TOWLINES AND MOORING ROPES; FIBRE ROPES

STEEL WIRE ROPES

Note.—For list of manufacturers of steel wire ropes see Appendix to this Chapter.

Approval of Works

1401 The manufacturer's plant and method of production are to be approved by the Committee. The works are to be at all times open to inspection of the Surveyor and periodical inspections are to be held at intervals not exceeding two years.

Each manufacturer is required to provide on his premises machines suitable for satisfactorily making the prescribed tests. The tensile testing machine is to be of an approved type and is to be calibrated at intervals not exceeding two years. Alternatively, tests carried out by a competent government, municipal or similar responsible body will be accepted.

Material

1402 The wire used in the manufacture of the rope is to be drawn from steel made by the open hearth, electric furnace, or other approved process and is to be of homogeneous quality, consistent strength and free from visual defects likely to impair the performance of the rope. The tensile strength of the wire should generally be within the range 130—160 kg. per mm.^{2}.

Galvanising

1403 The wire is to be galvanised by the hot dip or the electrolytic process to give a continuous uniform coating complying with the test requirements specified in 1409 and 1410. The coating may be any of the following grades:—

Grade 1—Heavy coating, drawn after galvanising.

Grade 2—Heavy coating, finally galvanised.

Grade 3—Light coating, drawn after galvanising.

Construction of Ropes

1404 The construction of wire ropes for standing rigging, towlines and mooring ropes is generally to be as given in the following table but alternative types of wire rope will be specially considered on the basis of an equivalent breaking load and the suitability of the construction for the purpose intended.

Purpose	Construction of Rope			Construction of Strands
	Strands	Wires	Core	
Standing rigging	6	7	Fibre	6 over 1
	7	7	Wire	6 over 1
	7	19	Wire	12 over 6 over 1
	7	37	Wire	18 over 12 over 6 over 1
Mooring ropes and towlines	6	12	Fibre	12 over fibre core
	6	19	Fibre	12 over 6 over 1
	6	24	Fibre	15 over 9 over fibre core
	6	37	Fibre	18 over 12 over 6 over 1

Tests on Completed Rope

1405 A sample of the completed rope shall be subjected to a breaking test to destruction. The sample shall be of sufficient length to provide a clear test length of at least 36 times the rope diameter. Not more than four-fifths of the nominal breaking load may be applied quickly and thereafter the load is to be applied slowly and steadily until the maximum load is obtained.

Tests in which a breakage occurs adjacent to the grips may, at the option of the manufacturer, be neglected.

The actual breaking load is not to be less than that given in the table overleaf.

1406 If facilities are not available for making a breaking test on completed ropes intended for standing rigging or mooring ropes, consideration will be given to the acceptance of the determination of the breaking load by the summation of the tests of individual wires and the deduction of a percentage for laying up. This percentage is not to be less than that given below. Manufacturers desiring to adopt this method of testing may be required to arrange for check breaking tests to be carried out on completed ropes.

CONSTRUCTION OF ROPE	PERCENTAGE DEDUCTION
6× 7	10
6×12	10
6×19	13
6×24	13
6×37	17½
7× 7	15
7×19	18
7×37	22½

SIZE OF ROPE		CONSTRUCTION AND BREAKING LOAD						
DIAMETER	APPROX. CIRCUM-FERENCE	6×7	6×12	6×19	6×24	6×37*	7×7	7×19
mm.	mm.	kg.	kg.	kg.	kg.	kg.	kg.	kg.
8	25	3150	1850	2850	2900	3250		
9	28	3950	2650	4100	3550	4200		
10	32	4800	3100	4800	4300	4800	5300	
11	35	5800	3600	5550	5100	5950	6400	
12	38	7400	4700	7250	6000	7200	8200	
14	44	9800	5950	9200	8000	10000	10900	10350
16	51	12600	8100	12500	11500	13400	14000	14100
18	57	15700	9750	15000	14300	17200	17500	16900
20	63	20200	12450	19200	17300	21450	22400	21600
22	69	24100	14450	22300	20500	26200	26800	25000
24	76	28400	17700	27300	24100	28800	31500	29500
26	82	33000	21300	32800	30000	34300	36700	36900
28	88	39300	23900	36800	34300	40200	43600	41400
32	101	50400	31000	47800	43700	53500	56000	53700
36	113	64700	39000	60000	57000	68800	71800	67600
40	126	78900	49900	76800	69000	81400		86400
44	138			92300	82200	100100		103800
48	151			110600	100200	120700		122700
52	163			127600	115900	137100		143500
56	176			147500	132700	160900		165700
60	189							189400

*This rope is made of wire having a tensile strength between 160 and 179 kg/mm².

1407 A suitable length shall be cut off the rope, unstranded and straightened, and six wires subjected to a torsion test (*see* 1408) and six wires to a wrap test for adhesion of coating (*see* 1410).

Torsion Test

1408 The length of sample shall be such as to allow a distance between the grips of 100 times the diameter of wire, but this distance need not exceed 300 mm. The wire is to be twisted by causing one or both of the vices to be revolved until fracture occurs. The speed of testing should not exceed, for a length equal to 100 times the diameter:—

Diameter of Coated Wire mm.		Maximum Speed of Testing Turns per Minute
From (Including)	Up to (Excluding)	
	1,5	90
1,5	3,0	60
3,0	5,0	30

(A tensile load not exceeding 2 per cent of the breaking load of the wire may be applied to keep the wire stretched.)

The wire shall withstand, on a length of 100 times the diameter of wire, the number of complete twists given below:—

Diameter of Coated Wire mm.		Number of Twists	
From (Including)	Up to (Excluding)	Grade 1 or 2	Grade 3
	1,3	13	24
1,3	2,3	13	23
2,3	3,0	12	20
3,0	4,0	10	18

Weight and Uniformity of Zinc Coating

1409 The weight of coating shall comply with the minimum figures shown in the table below when tested in accordance with a recongised standard.

The uniformity of the zinc coating is to be tested by a dip test, carried out in accordance with a recognised standard.

Diameter of Coated Wire mm.		Coating	
		Grade 1 or 2	Grade 3
From (Including)	Up to (Excluding)	gm/m².	gm/m².
0,40	0,50	75	40
0,50	0,60	90	50
0,60	0,80	110	60
0,80	1,00	130	70
1,00	1,20	150	80
1,20	1,50	165	90
1,50	1,90	180	100
1,90	2,50	205	110
2,50	3,20	230	125
3,20	4,00	250	135

Wrap Test for Adhesion of Coating

1410 The adhesion of the coating is to be tested by wrapping the wire round a cylindrical mandrel for ten complete turns of wrap. The ratio between the diameter of the mandrel and that of the wire is to be as follows:—

Coating	Wire diameter less than 1,5 mm.	Wire diameter 1,5 mm. and over
Grade 1 or 2	4	6
Grade 3	2	3

After winding on the appropriate mandrel the zinc coating should neither have flaked nor cracked to such an extent that any zinc can be removed by rubbing with the bare fingers.

Certificates

1411 Printed forms of certificates, approved by the Committee, are to be signed by the manufacturers and will be supplied to them on application.

FIBRE ROPES

General

1412 Fibre ropes intended as mooring ropes may be made of coir, hemp, manilla or sisal or may be composed of synthetic (man-made) fibres. They may be either 3-strand (hawser laid) 4-strand (shroud laid) or 9-strand (cable laid) but other constructions will be specially considered.

1413 Each length of rope is to be manufactured from only one type and grade of natural or synthetic fibre. The fibre is to be long staple unadulterated and free from defects.

1414 Synthetic fibre ropes are to be suitable for the purpose intended and should comply with a recognised standard.

1415 Weighting and loading matter is not to be added and any added lubricant is to be kept to a minimum. Any rot-proofing or water repellancy treatment shall not be deleterious to the fibre nor shall it add to the weight or reduce the strength of the rope.

Testing

1416 The breaking load is to be determined by testing to destruction a sample cut from the completed rope.

1417 The minimum length of sample to be used in determining the breaking load of a fibre rope is to be as given in the following table. The specimen is to be loaded to the initial load, given in the Table as a percentage of the specified breaking load, and checked for diameter and evenness of lay-up. The load is then to be increased evenly and continuously at the rate shown in the Table until the specimen breaks.

If the sample is held by grips and the break occurs within 150 mm. of the grips the test may be repeated but not more than two tests may be made on any one coil.

TESTING OF FIBRE ROPES

Material	Test Length mm.	Initial Loading	Speed of Loading to Fracture
Natural Fibre	1800	2%	(0,15 metres ± 0,05 metre) per min.
Synthetic Fibre	900	1%	0,10 metres per min. maximum.

1418 Where difficulty is experienced in testing a sample of a completed synthetic fibre rope the Society will consider alternative methods of testing.

Breaking Load

1419 The actual breaking load is not to be less than that given in the following table.

Diameter	3-Strand (Hawser laid)	4-Strand (Shroud laid)	9-Strand (Cable laid)
	Breaking Load		
mm.	kg.	kg.	kg.
20	2880	2680	
22	3410	3170	
24	4065	3770	
26	4700	4365	
28	5500	5120	
30	6200	5775	
32	7130	6620	
36	8850	8200	
40	10650	9900	
44	12600	11950	
48	14850	13800	9250
52	17300	16050	10600
56	19880	18500	12220
60	22550	20950	14080
64	26100	24300	15450
72	32200	29900	18900
80	39500	36700	23100

Certificates

1420 Printed certificates issued by the manufacturer or a competent government, municipal or similar responsible body will be accepted. The certificate should give the breaking load, test length and speed of testing.

Section 15

APPROVAL OF ELECTRODES AND WIRE-FLUX COMBINATIONS FOR WELDING IN HULL CONSTRUCTION

1501 The manufacturer's plant and method of production of electrodes and fluxes are to be such as to ensure reasonable uniformity in manufacture.

1502 Electrodes and wire-flux combinations will be approved subject to compliance with the following tests. The test pieces are to be prepared in the presence of the Surveyor and all tests carried out under his supervision.

ELECTRODES FOR MANUAL ARC WELDING

1503 Electrodes will be divided into Grades 1, 2 and 3 dependent on the results of the Charpy tests. In addition, if Grade 2 or Grade 3 electrodes comply with the requirements of the hydrogen test as given in 1514, a suffix H will be added to the Grade mark.

Electrodes which have satisfied the requirements of Grade 2 will also be considered as complying with Grade 1 requirements and those which have satisfied the requirements of Grade 3 will be considered as complying with Grades 1 and 2 requirements.

1504 Grade A hull structural steel may be used in the preparation of all test pieces, but at the option of the manufacturer Grades B, C or D steel may be used for Grade 2 electrode test pieces and Grade E steel for Grade 3 electrode test pieces.

1505 The welding current used is to be within the range recommended by the manufacturer and, where an electrode is stated to be suitable for both A.C. and D.C., A.C. is to be used for the preparation of the test assemblies.

Deposited Metal Tests

1506 Tensile and impact tests are to be made, under controlled conditions, on metal deposited from the electrodes.

Two all-weld-metal test assemblies are to be prepared in the downhand position as shown in Fig. 1, one using 4 mm. electrodes and the other using 8 mm. diameter electrodes or the largest size manufactured if this is less than 8 mm. diameter.

The weld metal is to be deposited in single or multi-run layers according to normal practice, and the direction of deposition of each layer is to alternate from each end of the plate, each run of weld metal being not less than 2 mm. and not more than 4 mm. thick. Between each run the assembly is to be left in still air until it has cooled to 250° C., the temperature being taken in the centre of the weld, on the surface of the seam.

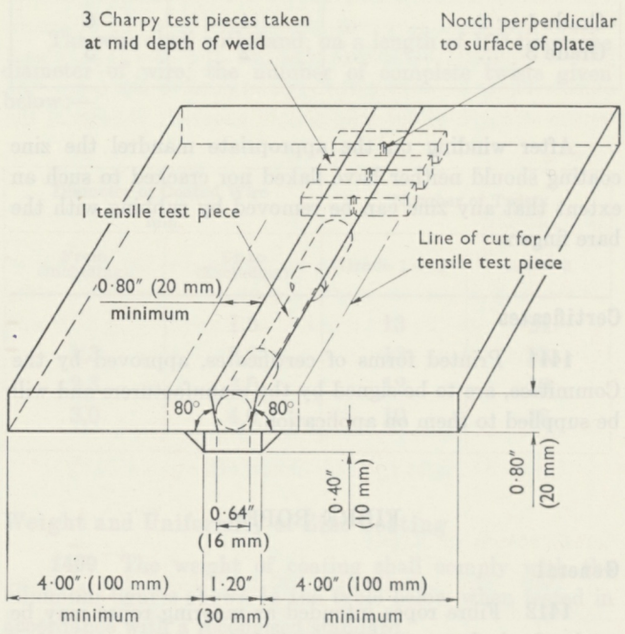


Fig. 1

After being welded the test assemblies are not to be subjected to any heat treatment.

Deposited Metal Tensile Tests

1507 The tensile test pieces, one from each all-weld-metal assembly, are to be machined to the dimensions shown in Fig. 2, care being taken that the longitudinal axis coincides with the centre of the weld, and the mid-thickness of the plates.

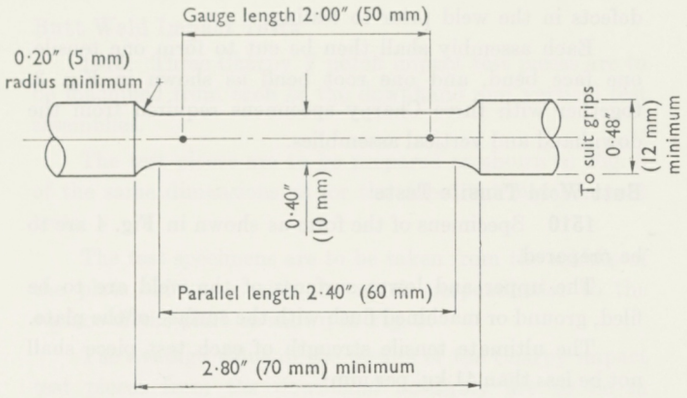


FIG. 2

The tensile test piece may be subjected to a temperature not exceeding 250° C. for a period not exceeding 16 hours for hydrogen removal, prior to testing.

The ultimate tensile strength of each test specimen is not to be less than 41 kg. per mm.^{2} nor more than 57 kg. per mm.^{2}. Where this upper limit is exceeded special consideration will be given to the approval of the electrode, taking into consideration the other physical properties shown by the test results, and the chemical composition of the weld metal.

The yield stress is not to be less than 31 kg. per mm.^{2} and the elongation not less than 22 per cent on a gauge length of 50 mm.

Deposited Metal Impact Tests

1508 The impact test pieces are to be of the Charpy V notch type, three test pieces being taken from each of the deposited metal test assemblies. The test pieces are to be 10 mm. square in cross section and 55 mm. in length, and having in the centre of the length of one face a perpendicular V notch with an included angle of 45°, a depth of 2 mm. and a root radius of 0,25 mm. The prescribed dimensions should be carefully checked. The test pieces shall be cut with their longitudinal axes perpendicular to the weld and the upper surface 5 mm. from the upper surface of the plate.

The notch shall be positioned in the centre of the weld and is to be cut in the face of the test piece perpendicular to the surface of the plate. The tests are to be carried out on an approved Charpy impact machine.

For Grade 1 electrodes the average impact value for the three specimens from each assembly shall not be less than 4,8 kg.m. at about 20° C. The corresponding value for Grade 2 electrodes is 4,8 kg. m. at 0° C. and for Grade 3 electrodes 6,2 kg. m. at −10° C. or 4,8 kg. m. at −20° C. The test temperature for Grades 2 and 3 test pieces is to be controlled to within ± 1° C. of the prescribed temperature. Both the test specimen and the handling tongs are to be cooled for a sufficient length of time to reach the test temperature and the specimen then quickly transferred from the cooling device to the anvil of the testing machine and broken within a time lapse of not more than 5 seconds.

If the average of the three Charpy specimens fails to comply with the above requirements by an amount not exceeding 15 per cent of the required value, three additional test pieces may be made and tested, and the results added to those previously obtained to form a new average, which must comply with the requirements.

When the average value of the three Charpy specimens is more than 15 per cent below the required value, then six more Charpy test pieces are to be prepared and the average value of these new test pieces is to comply with the requirements.

Butt Weld Tests

1509 Butt weld assemblies as shown in Fig. 3 are to be prepared for each welding position (downhand, vertical and overhead) for which the electrode is recommended by the manufacturer.

The test assemblies are to be made by welding together two plates 15 to 20 mm. in thickness not less than 100 mm. in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size. The plate edges are to be prepared to form a single vee joint, the included angle between the fusion faces being 60° and the root gap being 2 to 3 mm.

Where the electrode is only to be approved in the downhand position an additional test assembly is to be prepared in that position.

The following welding procedure should be adopted in making the test assemblies:—

Downhand (a). First run with 4 mm. electrode. Remaining runs (except last two layers) with 5 mm. electrodes or above according to the normal welding practice with the electrodes. The runs of the last two layers with the largest size of electrode manufactured or 8 mm. whichever is the less.

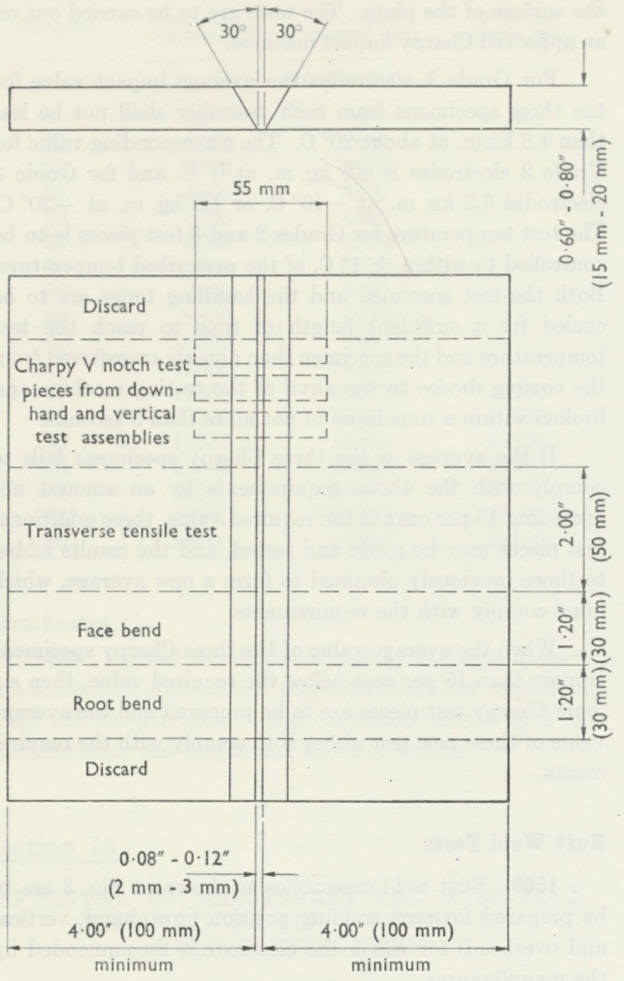


FIG. 3

Where a second downhand test is required:—

Downhand (b). First run with 4 mm. electrode. Next run with an intermediate size electrode 5 mm. or 6 mm. and the remaining runs with the largest size of electrode manufactured or 8 mm. whichever is the less.

Vertical and overhead. First run with 3,15 mm. electrode. Remaining runs with 4 mm. electrodes or possibly with 5 mm. electrodes if this is recommended by the manufacturer for the positions concerned.

In all cases the back sealing runs are to be made with 4 mm. electrodes in the welding position appropriate to each test sample, after cutting out the root run to clean metal. For electrodes suitable for downhand welding only, the test assemblies may be turned over to carry out the back sealing run.

The butts are to be welded using normal welding practice and between each run the assembly is to be left in still air until it has cooled to 250° C. the temperature being taken in the centre of the weld, on the surface of the seam.

After being welded the test assemblies are not to be subjected to any heat treatment.

It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain any defects in the weld prior to testing.

Each assembly shall then be cut to form one tensile, one face bend, and one root bend as shown in Fig. 3, together with three Charpy specimens required from the downhand and vertical assemblies.

Butt Weld Tensile Tests

1510 Specimens of the form as shown in Fig. 4 are to be prepared.

The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate.

The ultimate tensile strength of each test piece shall not be less than 41 kg. per mm².

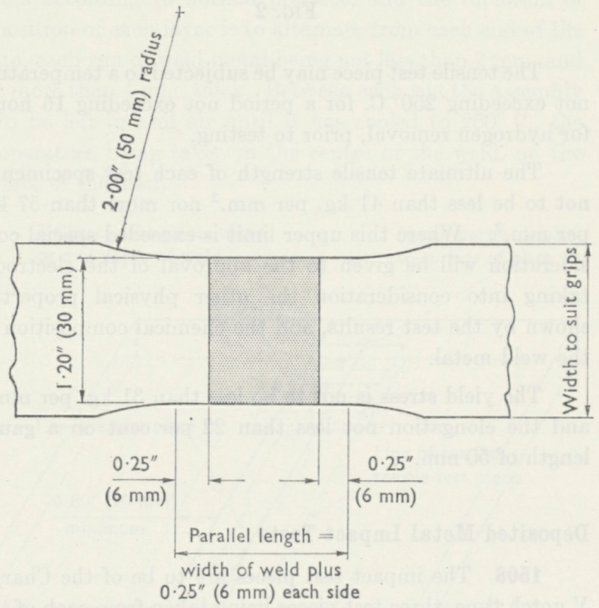


FIG. 4

Butt Weld Bend Tests

1511 The specimens are to be 30 mm. in width. The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate and the sharp corners of the specimens rounded to a radius not exceeding 2 mm.

The test specimens are to be capable of withstanding, without fracture, being bent through an angle of 120° over a former having a diameter three times the thickness of the specimen.

One specimen from each welded assembly is to be tested with the face of the weld in tension and the other with the root of the weld in tension.

The test pieces can be considered as complying with the test if, on completion of the test, no crack or defect, at the outer surface of the test specimen, can be seen.

Butt Weld Impact Tests

1512 Three Charpy V notch impact test pieces are to be machined from each of the downhand and vertical test assemblies.

The test pieces are to be prepared as shown in Fig. 5 of the same dimensions as for the deposited metal impact tests.

The test specimens are to be taken from the middle of the plate thickness with the notch perpendicular to the surface of the plate as shown in Fig. 5.

The average value of the results of the Charpy impact test pieces from the downhand assembly are to be in accordance with the requirements for deposited metal as given in 1508. The results from the vertical assembly are to be reported.

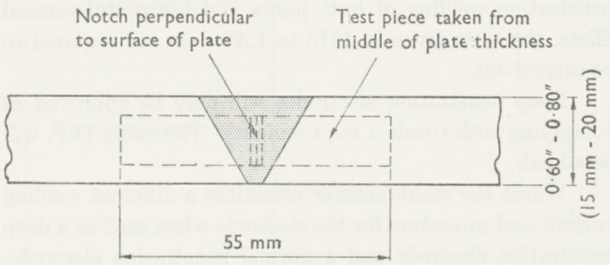


FIG. 5

Hot Cracking Test

1513 Two plates 12 to 15 mm. thick of dimensions 120 by 80 mm. are to be welded together in the form of a square tee joint as shown in Fig. 6 The lower face of the vertical plate is to be straight and is to fit closely on the plane surface of the lower plate. Any unevenness is to be removed before welding. The tack welds in preparation for the fillet welds are to be positioned at the two ends on a level with the contact surface of the plates. The lower plate is to be stiffened by three transverse stiffeners in order to prevent distortion.

The fillet welding, which is to be made in one pass, is to be carried out in the downhand position and the welding current used is to be the maximum of the range recommended by the manufacturer for the size of electrode used.

The second fillet weld shall be started immediately after the completion of the first fillet weld and at the end of the specimen at which the first fillet weld finished. Both fillet welds are to be executed at a constant speed and without weaving.

For welding the full length of each fillet (120 mm.) the following lengths of electrodes are to be fused:—

Diameter of electrode	Length of Fused Electrode	
	1st fillet	2nd fillet
4 mm.	200 mm.	150 mm.
5 mm.	150 mm.	100 mm.
6 mm.	100 mm.	75 mm.

After welding, the slag is to be removed from the fillet welds and after complete cooling they are to be examined for cracks by a magnifying glass or by the use of penetrant fluids.

The first fillet weld is then to be cut out by machining or gouging and the second weld broken by closing the two plates together, subjecting the root of the weld to tension. The weld shall then be examined for evidence of hot cracking. There should be no cracking in the fillet welds (except crater cracks) either superficial or internal.

Hydrogen Test

1514 Electrodes which have satisfied the requirements of Grade 2 or Grade 3 may, at the option of the manufacturer, be submitted to a hydrogen test, and a suffix H will be added to the Grade number to indicate compliance with the test requirements.

Four test specimens are to be prepared measuring 12 by 25 mm. in cross section by about 125 mm. in length. The parent metal may be any grade of shipbuilding steel and, before welding, the specimens are to be weighed to the nearest 0,1 gm. On the 25 mm. surface of each test specimen a single band of welding is to be deposited about 100 mm. in length by a 4 mm. electrode, using about 150 mm. of the electrode. The welding is to be carried out with as short an arc as possible and with a current of about 150 amp.

The electrodes, prior to welding, can be submitted to the normal drying process recommended by the manufacturer.

Within thirty seconds of the completion of the welding of each specimen the slag is to be removed and the specimen quenched in water at approximately 20° C. After a further 30 seconds the specimens are to be cleaned and placed in an

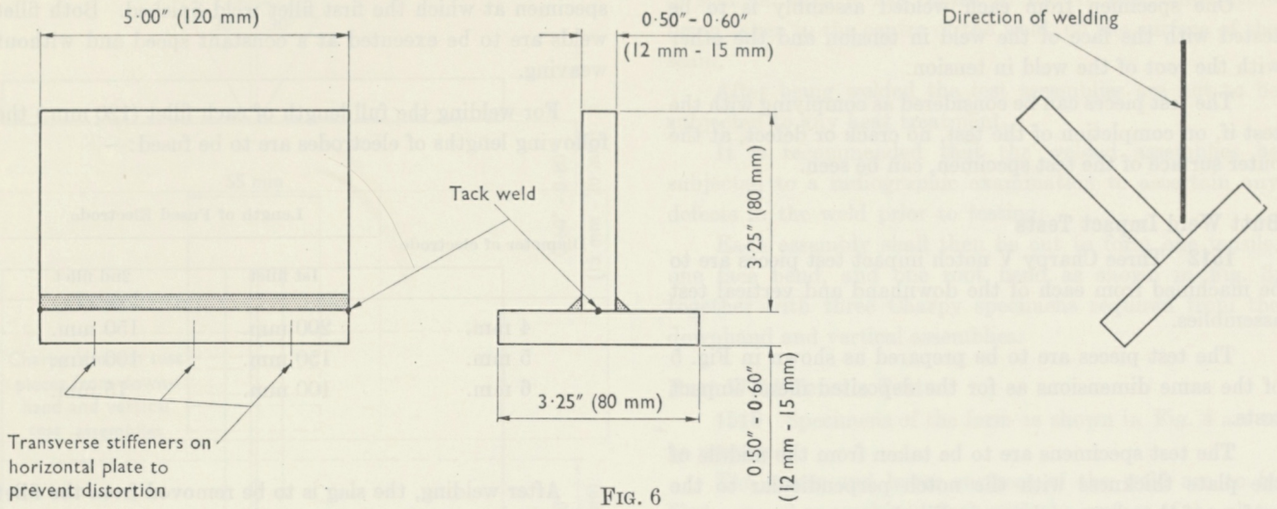


FIG. 6

apparatus suitable for the collection of hydrogen by displacement of glycerine. The glycerine is to be kept at a temperature of 45° C. during the test. All four specimens are to be welded and placed in the hydrogen collecting apparatus within 30 minutes.

The specimens are to be kept immersed in the glycerine for a period of 48 hours and, after removal, are to be cleaned in water and spirit, dried and weighed to the nearest 0,1 gm. to determine the amount of weld deposited.

The amount of gas evolved is to be measured to the nearest 0,05 c.c. and corrected for temperature and pressure to 20° C. and 760 mm. Hg.

The amount of hydrogen in terms of cubic centimetres per gram of weld metal is to be reported and is not to exceed an average of 0,1 c.c. per gram for the four specimens tested.

Alternatively, the hydrogen content of the weld metal may be determined by any mercury gas burette type of apparatus, in accordance with a recognised procedure. Proposals for alternative methods of carrying out the test are to be submitted for approval.

Deep Penetration Electrodes

1515 Where, in addition to its use as a normal penetration electrode, a manufacturer desires to demonstrate that an electrode also has deep penetrating properties when used for downhand butt welding and horizontal-vertical fillet welding, the additional tests given in 1516 to 1520 are to be carried out.

Where a manufacturer recommends that an electrode having deep penetrating properties can also be used for downhand butt welding of thicker plates with prepared edges, the electrode will be treated as a normal penetration electrode and the full series of tests in the downhand position are to be carried out, together with the deep penetration tests given in 1516 to 1520.

Where an electrode is only recommended for deep penetration welding of butt joints and horizontal-vertical fillets, the tests given in 1516 to 1520 only are required to be carried out.

Deep penetration electrodes will only be approved as complying with Grade 1 requirements. The suffix D.P. will be added.

Where the manufacturer prescribes a different welding current and procedure for the electrode when used as a deep penetration electrode and a normal penetration electrode, the recommended current and procedure are to be used when making the test specimens in each case.

Deep Penetration Butt Weld Tests

1516 Two plates of thickness equal to twice the diameter of the core of the electrode plus 2 mm. are to be butt welded together with one downhand run of welding from each side. The plates are to be not less than 100 mm. wide and of sufficient length to allow the cutting out of the test specimens of the correct number and size as shown in Fig. 7.

The joint edges are to be prepared square and smooth and, after tacking, the gap is not to exceed 0,25 mm.

The test assembly is to be welded using an 8 mm. diameter electrode or the largest size manufactured if this is less than 8 mm.

After welding, the test assembly shall be cut to form two transverse tensile test pieces, two bend test pieces and three Charpy V-notch impact test pieces.

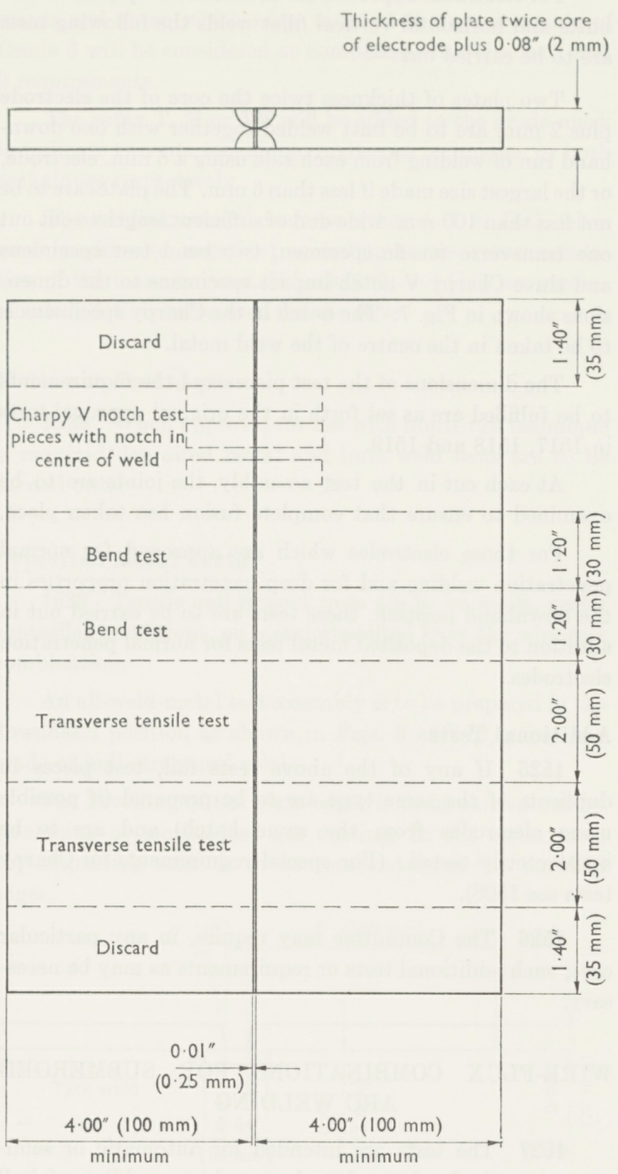


FIG. 7

The discards at the end of the welded assemblies are to be not more than 35 mm. wide. The joints of these discards are to be polished and etched and must show complete fusion and interpenetration of the welds. At each cut in the test assembly the joints are also to be examined to ensure that complete fusion has taken place.

Deep Penetration Transverse Butt Weld Tensile Test

1517 Two transverse butt weld tensile test specimens are to be prepared to the dimensions given in Fig. 4.

The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate.

The ultimate tensile strength of the test piece shall not be less than 41 kg. per mm.^{2}.

Deep Penetration Butt Weld Bend Tests

1518 Two butt weld bend tests are to be prepared in accordance with the requirements of 1511 and are to be capable of withstanding, without fracture, being bent through an angle of 120° over a former having a diameter three times the thickness of the specimen.

One test piece shall be tested with the side first welded in tension and one with the other side in tension.

Deep Penetration Butt Weld Impact Tests

1519 Three Charpy V-notch impact test pieces are to be prepared, the notch being in the centre of the weld.

The dimensions of the test pieces are to be as given in 1508. The longitudinal axes of the test pieces are to be perpendicular to the direction of the weld, and they are to be taken from the centre of the plate thickness. The notch is to be cut in the face of the test piece perpendicular to the surface of the plate.

The average impact values for the three specimens taken from the centre of the weld shall not be less than 4,8 kg. m. at about 20° C.

Deep Penetration Fillet Weld Test

1520 A fillet weld assembly is to be prepared as shown in Fig. 8 with plates about 12,5 mm. in thickness.

The welding shall be carried out with one run for each fillet with plate A in the horizontal plane during the welding operations. The length of the fillet is to be 160 mm. and the gap between the plates is to be not more than 0,25 mm.

The fillet weld on one side of the assembly shall be carried out with a 4 mm. electrode and that on the other side with the maximum size of electrode manufactured. The welding current used is to be within the range recommended by the manufacturer and the welding is to be carried out using normal welding practice.

The welded assembly shall be cut by sawing or machining within 35 mm. of the ends of the fillet welds and the joints are to be polished and etched. The welding of the fillet made with a 4 mm. electrode is to show a penetration of 4 mm. (*see* Fig. 8) and the corresponding penetration of the fillet made with the maximum size of electrode manufactured is to be reported.

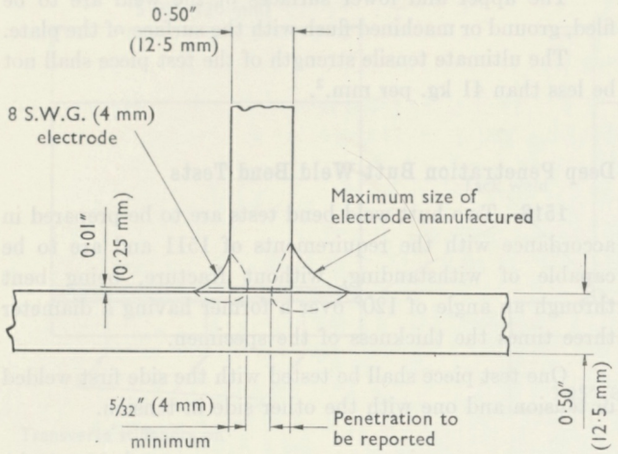


FIG. 8

Chemical Analysis

1521 The chemical analysis of the weld metal made by the electrode is to be supplied by the manufacturer.

1522 The Committee is to be notified of any alteration proposed to be made in the process of manufacture subsequent to approval.

Maker's Certificate

1523 Each carton or package of approved electrodes is to contain a certificate from the manufacturer on the following lines:—

> "The ..... company certifies that the composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by the Committee of Lloyd's Register of Shipping".

Periodical Inspection of Maker's Works and Annual Tests

1524 All establishments where approved electrodes are manufactured shall be subject to annual inspection. On these occasions, samples of the approved electrodes shall be subjected to at least the following tests:—

One tensile and three impact specimens in duplicate are to be made from deposited metal as set forth in 1506, 1507 and 1508. One group of specimens is to be prepared using one size of electrode and one using another, neither size being smaller than 4 mm. nor larger than 8 mm.

The ultimate tensile stress, yield stress and elongation are to be in accordance with 1507 and the impact properties in accordance with 1508 for the approved Grade.

For electrodes approved for downhand deep penetration butts and horizontal vertical fillet welds the following tests are to be carried out:—

Two plates of thickness twice the core of the electrode plus 2 mm. are to be butt welded together with one downhand run of welding from each side using a 6 mm. electrode, or the largest size made if less than 6 mm. The plates are to be not less than 100 mm. wide and of sufficient length to cut out one transverse tensile specimen, two bend test specimens and three Charpy V-notch impact specimens to the dimensions shown in Fig. 7. The notch in the Charpy specimens is to be taken in the centre of the weld metal.

The dimensions of the test pieces and the requirements to be fulfilled are as set forth in the original approval tests in 1517, 1518 and 1519.

At each cut in the test assembly, the joints are to be examined to ensure that complete fusion has taken place.

For those electrodes which are approved for normal penetration welding and for deep penetration properties in the downhand position, these tests are to be carried out in addition to the deposited metal tests for normal penetration electrodes.

Additional Tests

1525 If any of the above tests fail, test pieces in duplicate of the same type are to be prepared (if possible using electrodes from the same batch) and are to be satisfactorily tested. (For special requirements for Charpy tests see 1508).

1526 The Committee may require, in any particular case, such additional tests or requirements as may be necessary.

WIRE-FLUX COMBINATIONS FOR SUBMERGED ARC WELDING

1527 The tests are intended for automatic or semi-automatic single electrode submerged arc welding of hull structural steel. The wire-flux combinations are divided into two categories:—

(a) For use with the multi-run technique.

(b) For use with the two-run technique; in this case a butt weld is made with one run from each side.

Where a manufacturer states that a particular wire-flux combination is suitable for welding with both techniques, both series of tests are to be carried out.

1528 Wire-flux combinations will be divided into Grades 1, 2 and 3, dependent on the results of the Charpy tests. Those which have satisfied the requirements of

Grade 2 will also be considered as satisfying Grade 1 requirements and those which have satisfied the requirements of Grade 3 will be considered as complying with Grades 1 and 2 requirements.

The suffix T, M or TM will be added to the grade mark to indicate two-run technique, multi-run technique, or both techniques respectively.

The welding current may be either A.C. or D.C. (electrode positive or negative) according to the recommendation of the manufacturer. If both A.C. and D.C. are recommended, A.C. is to be used for the tests.

Multi-run Technique

1529 When approval for use with multi-run technique is required deposited metal and butt weld tests are to be carried out.

Deposited Metal Tests

1530 Tensile and impact tests are to be made, under controlled conditions, on metal deposited from the wire-flux combination.

An all-weld-metal test assembly is to be prepared in the downhand position as shown in Figs. 9 and 10, using any grade of hull structural steel.

The bevelling of the plate edges is to be carried out by machining or mechanised gas cutting. In the latter case, any remaining scale is to be removed from the bevelled edges.

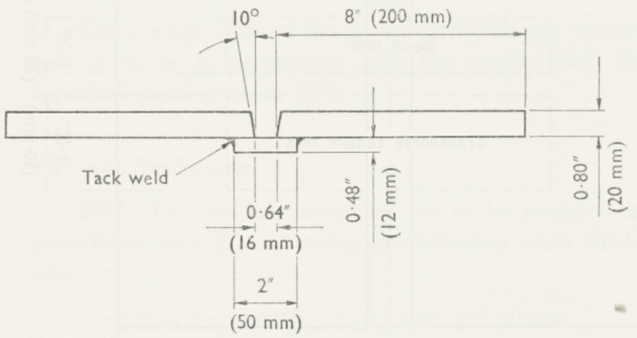


FIG. 9

The direction of deposition of each run is to alternate from each end of the plate and after completion of each run the flux and welding slag is to be removed. Between each run the assembly is to be left in still air until it has cooled to 250° C., the temperature being taken in the centre of the weld, on the surface of the seam. The thickness of the layer is to be not less than the diameter of the wire but not less than 4 mm.

The welding conditions (amperage, voltage and rate of travel) are to be in accordance with the recommendations of the manufacturer and are to conform with normal, good welding practice for multi-run welding.

The welded assembly is to be cut longitudinally at a distance of 30 mm. from the edges of the weld and then cut transversely.

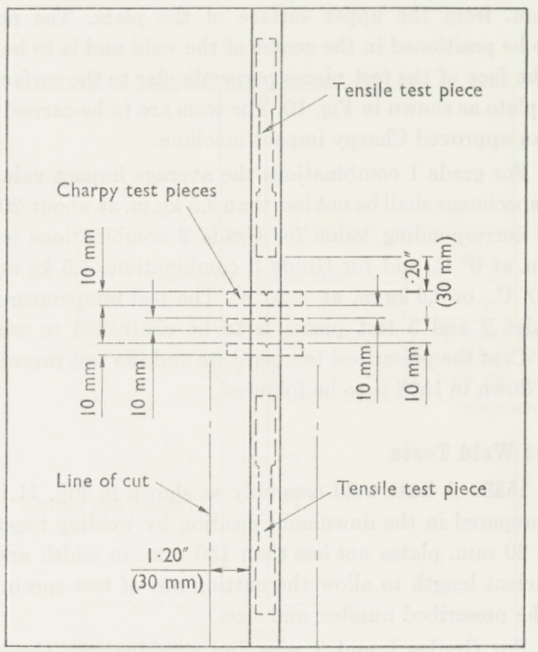


FIG. 10

Deposited Metal Tensile Tests

1531 Two tensile test pieces are to be machined to the dimensions shown in Fig. 2, care being taken that the longitudinal axis coincides with the centre of the weld, and the mid-thickness of the plates.

The tensile test pieces may be subjected to a temperature not exceeding 250° C. for a period not exceeding 16 hours for hydrogen removal, prior to testing.

The ultimate tensile strength of each test specimen is to be not less than 41 kg. per mm^2. nor more than 57 kg. per mm.^{2}. Where this upper limit is exceeded special consideration will be given to the approval of the wire-flux combination, taking into consideration the other physical properties shown by the test results, and the chemical composition of the weld metal.

The yield stress is to be not less than 31 kg. per mm.^{2} and the elongation not less than 22 per cent on a gauge length of 50 mm.

Deposited Metal Impact Tests

1532 The impact test pieces are to be of the Charpy V-notch type, three test pieces being taken from the deposited metal test assembly.

The dimensions of the test pieces are to be as given in 1508.

The test pieces are to be cut with their longitudinal axes perpendicular to the weld and the upper surface 5 mm. from the upper surface of the plate. The notch is to be positioned in the centre of the weld and is to be cut in the face of the test pieces perpendicular to the surface of the plate as shown in Fig. 10. The tests are to be carried out on an approved Charpy impact machine.

For grade 1 combinations the average impact value of the specimens shall be not less than 3,5 kg.m. at about 20° C. The corresponding value for Grade 2 combinations is 3,5 kg.m. at 0° C. and for Grade 3 combinations 4,5 kg.m. at −10° C., or 3,5 kg.m. at −20° C. The test temperature for Grades 2 and 3 test pieces is to be controlled to within ±1° C. of the prescribed temperature and the test procedure laid down in 1508 is to be followed.

Butt Weld Tests

1533 A butt weld assembly as shown in Fig. 11 is to be prepared in the downhand position by welding together two 20 mm. plates not less than 150 mm. in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size.

For Grades 1 and 2 wire-flux combinations Grade A steel is to be used and for Grade 3 wire-flux combinations any grade of steel may be used.

The plate edges are to be prepared to form a single vee joint, the included angle between the fusion faces being 60° and the root face being 4 mm. The bevelling of the plate edges is to be carried out by machining or mechanised gas cutting. In the latter case, any remaining scale is to be removed from the bevelled edges.

The welding is to be carried out by the multi-run technique and the welding conditions are to be the same as those adopted for the deposited metal test assembly.

The back sealing run is to be applied in the downhand position after cutting out the root run to clean metal.

After being welded the test assembly is not to be subjected to any heat treatment.

It is recommended that the welded assembly be subjected to a radiographic examination to ascertain any defects in the weld prior to testing.

The assembly shall then be cut to form two tensile, two face bend, two root bend and three impact test pieces as shown in Fig. 11.

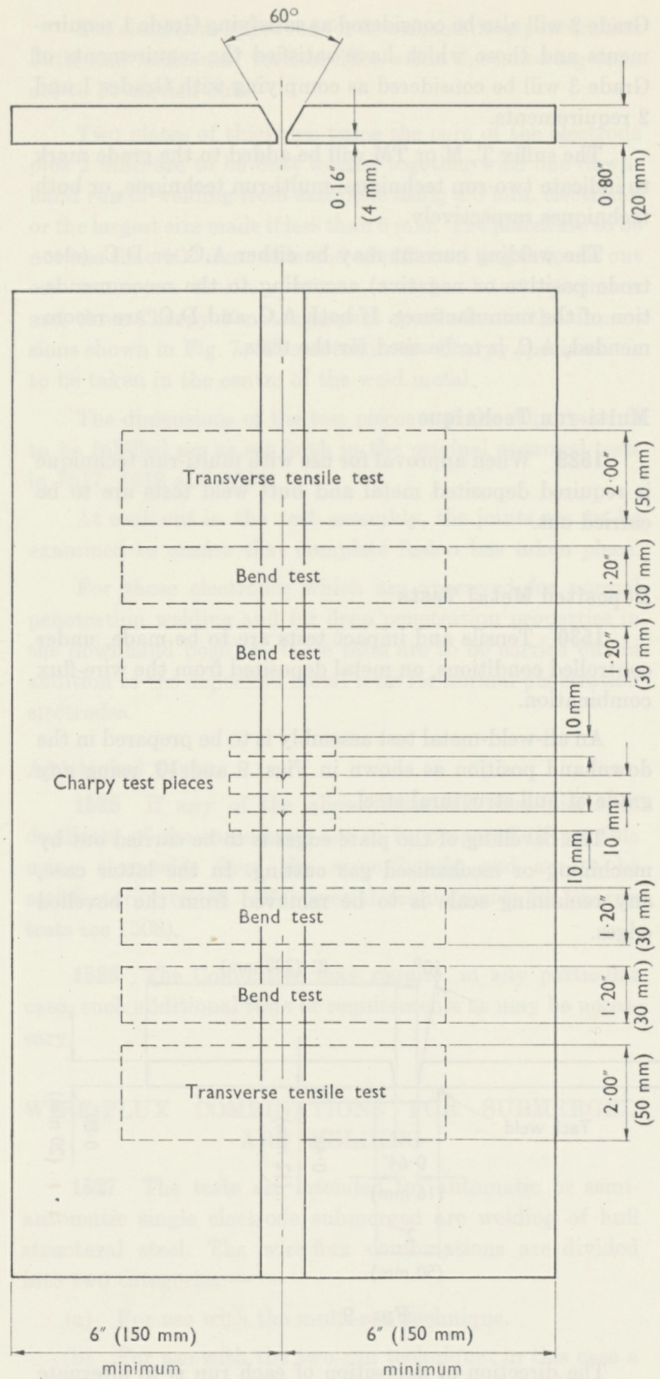


FIG. 11

Butt Weld Tensile Tests

1534 The two transverse tensile test pieces are to be machined to the dimensions shown in Fig. 4.

The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate.

The ultimate tensile strength of each test piece is to be not less than 41 kg. per mm.^{2}

Butt Weld Bend Tests

1535 Four transverse bend test specimens, 30 mm. in width, are to be taken from the welded assembly.

The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate and the sharp corners of the specimens rounded to a radius not exceeding 2 mm.

The test specimens are to be capable of withstanding, without fracture, being bent through an angle of 120° over a former having a diameter three times the thickness of the specimen.

Two specimens are to be tested with the face of the weld in tension and two specimens with the root of the weld in tension.

The test pieces can be considered as complying with the test if, on completion of the test, no crack or defect at the outer surface of the test specimen can be seen.

Butt Weld Impact Tests

1536 Three Charpy V-notch impact test pieces are to be machined from the test assembly.

The test specimens are to be prepared as shown in Fig. 5, to the dimensions given in 1508. The test specimens are to be taken from the middle of the plate thickness with the notch perpendicular to the surface of the plate.

The average value of the results of the Charpy impact tests is to be in accordance with the requirements for deposited metal given in 1532.

Two-run Technique

1537 Two welded assemblies are to be prepared in accordance with Fig. 12 using the following plate thickness:—

For Grade 1 approval—12—15 mm. and 20 mm.

For Grades 2 and 3 approval—20 mm. and 35 mm.

1538 The maximum diameter of wire, grades of steel plate and edge preparation to be used are to be in accordance with Fig. 13. Small deviations in the edge preparation may be allowed if requested by the manufacturer. The bevelling of the plate edges is to be performed by machining or mechanised gas cutting. In the latter case any remaining scale is to be removed from the bevelled edges. The root gap should not exceed 0,7 mm.

Each butt weld is to be welded in two runs, one from each side, using amperages, voltages and travel speeds in accordance with the recommendations of the manufacturer and normal good welding practice.

After completion of the first run, the flux and welding slag are to be removed and the assembly is to be left in still air until it has cooled to 100° C., the temperature being taken in the centre of the weld, on the surface of the seam.

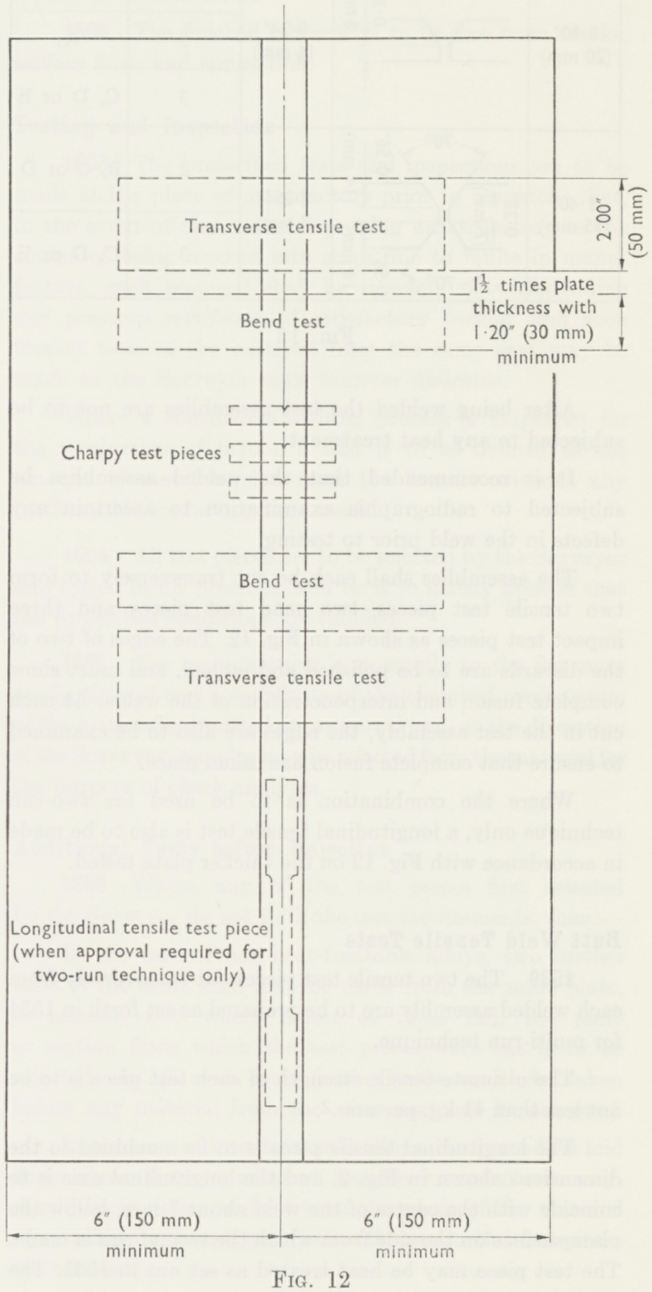


FIG. 12

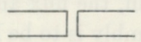
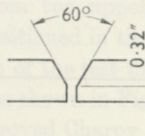
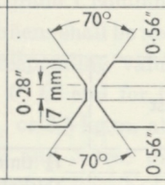
Plate thickness	Preparation	Maximum diameter of wire	Grade of wire/flux combination	Grade of steel
0·50″ – 0·60″ (12 mm – 15 mm)		0·20″ (5 mm)	1	A
0·80″ (20 mm)		0·24″ (6 mm)	1	A
			2	A
			3	C, D or E
1·40″ (35 mm)		0·28″ (7 mm)	2	B, C or D
			3	C, D or E

FIG. 13

After being welded the test assemblies are not to be subjected to any heat treatment.

It is recommended that the welded assemblies be subjected to radiographic examination to ascertain any defects in the weld prior to testing.

The assemblies shall each be cut transversely to form two tensile test pieces, two bend test pieces and three impact test pieces as shown in Fig. 12. The edges of two of the discards are to be polished and etched, and must show complete fusion and interpenetration of the welds. At each cut in the test assembly, the edges are also to be examined to ensure that complete fusion has taken place.

Where the combination is to be used for two-run technique only, a longitudinal tensile test is also to be made in accordance with Fig. 12 on the thicker plate tested.

Butt Weld Tensile Tests

1539 The two tensile test pieces cut transversely from each welded assembly are to be prepared as set forth in 1534 for multi-run technique.

The ultimate tensile strength of each test piece is to be not less than 41 kg. per mm.2.

The longitudinal tensile piece is to be machined to the dimensions shown in Fig. 2, and the longitudinal axis is to coincide with the centre of the weld about 7 mm. below the plate surface on the side from which the second run is made. The test piece may be heat treated as set out in 1531. The results of the test are to be the same as those specified in 1531 for the deposited metal tensile tests for multi-run technique test pieces.

Butt Weld Bend Tests

1540 Two transverse bend tests are to be taken from each welded assembly. The width of the test piece is to be $1\frac{1}{2}$ times the thickness of the plate with a minimum of 30 mm. for plates up to 20 mm. thick, and the test pieces are to be prepared in accordance with 1535.

One specimen from each assembly is to be tested with the side first welded in tension and one with the other side in tension.

The results of the tests and the conditions for acceptance are to be the same as those specified in 1535 for the multi-run technique test pieces.

Butt Weld Impact Tests

1541 Three Charpy V-notch impact test pieces are to be machined from each welded assembly.

The position of the test piece and of the notch in relation to the welded seam is shown in Fig. 14, and the dimensions of the test piece are to be as given in 1508.

The average value of the results of the Charpy tests is to be in accordance with the requirements given in 1532.

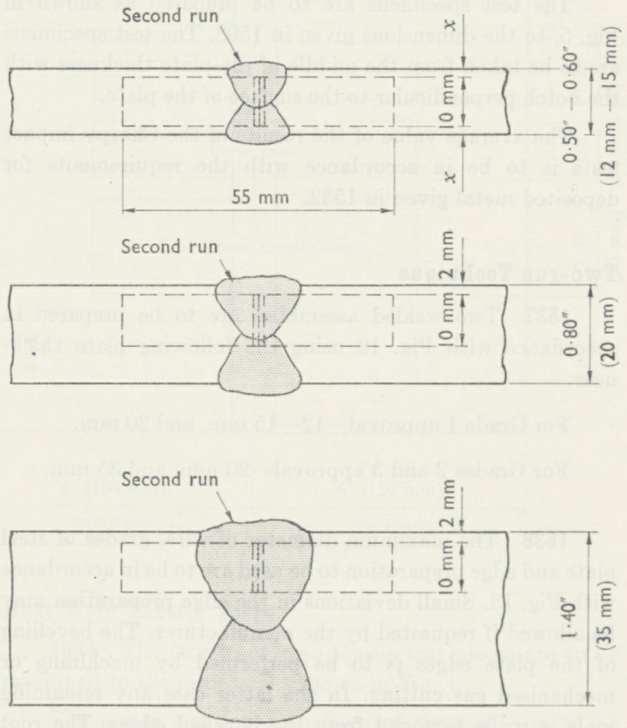


FIG. 14

Chemical Analysis

1542 The chemical analysis of the weld metal made by the wire-flux combination is to be supplied by the manufacturer.

The plate material used shall have an analysis which is representative of the grade of steel laid down for the test.

Periodical Inspection of Makers' Works and Annual Tests

1543 All establishments where approved electrodes are manufactured shall be subject to annual inspection. On these occasions, samples of the approved wire-flux combinations shall be subject to at least the following tests:—

MULTI-RUN TECHNIQUE:—

Deposited metal tests—two tensile and three impact tests.

TWO-RUN TECHNIQUE:—

Transverse specimens taken from a 20 mm. butt weld assembly—two tensile, two bend and three impact tests.

The specimens are to be prepared and tested in accordance with, and on grades of steel laid down for, first approval.

Additional Tests

1544 If any of the above tests fail, test pieces in duplicate of the same type are to be prepared (if possible using wire-flux combination from the same batches) and are to be satisfactorily tested. For special requirements for additional Charpy tests *see* 1508.

1545 The Committee may require, in any particular case, such additional tests or requirements as may be necessary.

Section 16

ALUMINIUM ALLOY PLATES, BARS AND SECTIONS

Note:—For list of manufacturers of Aluminium Alloys for shipbuilding purposes see Appendix to this Chapter.

General

1601 Aluminium alloys used in the construction of ships classed, or proposed for classification, in the Society's Register Book are to be made at works recognised by the Committee and are to comply with the following requirements.

These requirements, however, are not intended to apply to sheets less than 4,5 mm. thick, or to angles less than $40\times40\times4,5$ mm. Where material of these scantlings is used, the physical properties and chemical composition may be in accordance with a recognised specification for an alloy suitable for marine use.

Alloys whose chemical composition differs from these requirements will be specially considered.

Freedom from Defects

1602 The finished material is to be free from cracks, surface flaws and lamination.

Testing and Inspection

1603 The prescribed tests and inspections are to be made at the place of manufacture prior to despatch; but, in the event of any material proving unsatisfactory in the course of being worked into ships due to faults in manufacture, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same cast may be made as the Surveyor may consider desirable.

Where a continuous melting process is employed for the production of ingots, a cast is to be defined as the amount of metal tapped from the furnace without any further addition having been made.

1604 All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

1605 The manufacturer is to supply to the Surveyor at the time of test a certificate of the chemical composition of the material submitted for approval and, at the discretion of the Surveyor, samples may be selected from the material for the purpose of check analyses.

Additional Tests before Rejection

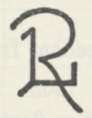
1606 Where any of the test pieces first selected by the Surveyor do not fulfil the test requirements, then:—

In the case of non-heat-treatable alloys, two further tests of the same kind may be made from the same plate, or section, but where either of these fail, the plate or section from which the test pieces were cut is to be rejected. In all such cases further tests are to be taken before any material from the same cast can be accepted.

In the case of heat-treatable alloys, the procedure laid down above is to be adopted, but the manufacturer may, should he so desire, re-heat-treat the whole of the material represented by the test piece before the two further test pieces are selected.

1607 Where a tensile test piece breaks outside the middle half of its gauge length, and the elongation is less than that required by the Rules, the test may, at the manufacturer's option, be discarded and another test made of the same plate or section.

Branding

1608 Every plate or section is to be clearly and distinctly marked by the manufacturer in two places with the Society's brand, thus:—  indicating that the material has complied with the Society's requirements.

1609 Material bearing this brand is not to be forwarded from the works until the prescribed tests have been made by the Surveyor and the mill sheets have been signed by him. All material is also to be stamped in two places with the manufacturer's name or trade mark and the place where made. Material is also to be stamped with numbers, or identification marks, by which it can be traced to the cast from which it was made.

Defacing of Rejected Material

1610 In the event of the material failing to withstand the prescribed tests, the Surveyor is to see that the Society's brand, stamped on the material by the manufacturer, has been defaced by punch marks extending beyond the brand in the form of a cross, thus:— denoting that the material has been rejected.

Manufacturer's Certificate

1611 The mill sheets, presented to the Surveyor for signing, shall bear the following certificate printed on each sheet, with the name of the firm and initialled by the test house manager:—

"We hereby certify that the material described below satisfies the prescribed chemical composition and is that which has been satisfactorily tested in the presence of the Surveyor in accordance with the Rules of Lloyd's Register."

Facilities for Inspection

1612 The manufacturer is to adopt a system of marking which will enable all material presented for inspection to be traced to the original cast, and, in the case of heat-treatable material, to the particular batch in which it was heat-treated; a batch comprises all material simultaneously heat-treated in one furnace load. The Surveyor must be given every facility for tracing all material to its respective casts and for witnessing the required tests. When the Surveyor is satisfied with the material and with the results of tests, he is to be furnished with two copies of the advice notes for his signature, one of which is to be forwarded by the manufacturer to the shipbuilder, and the other is to be forwarded by the Surveyor to the Surveyors at the port where the ship is to be built.

Aluminium Alloys not made where Wrought

1613 Where the alloy is not made at the works where it is wrought, a certificate is to be supplied to the Surveyor stating the name of the maker of the material, also the numbers of the casts for reference to the books of the maker. The number of the cast is to be marked on each ingot or slab for the purpose of identification and the wrought material is also to be legibly stamped in two places with the manufacturer's name or trade mark and the place where finally wrought. The material is also to be stamped with numbers or identification marks by which it can be traced to the cast from which it was made.

Additional Tests

1614 In addition to the tests described hereafter, the material may be subjected to additional tensile tests at the discretion of the Surveyors.

Aluminium Alloys of other Chemical Composition or Mechanical Properties

1615 When desired by owners and builders, consideration will be given by the Committee to proposals for the use of alloys differing in chemical composition or mechanical properties from those provided for in the Rules.

Tensile Test Pieces

1616 The proof stress, the tensile strength and the ductility are to be determined from standard test pieces. The test for proof stress shall be carried out on each selected test piece either from a stress strain curve, by drawing a line parallel to the straight portion of the curve and distant from it by an amount representing the required maximum permanent elongation, thus determining the stress at which line and curve intersect; or by subjecting the test piece to the specified minimum proof stress and removing the load, when the test piece shall not have acquired a permanent elongation, measured by an extensometer, greater than that required by the Rules.

1617 For material more than 22 mm. in thickness the width of the test piece between the gauge points is not to exceed 38 mm.; for material 22 mm. to 9,5 mm. in

thickness, inclusive, the width is not to exceed 51 mm.; for material less than 9,5 mm. in thickness the width is not to exceed 63 mm. In other respects the test pieces are to conform to standard test piece A. (*See* P 312.)

Alternatively, a test piece having a gauge length of 51 mm., a width of 12,5 mm., a minimum parallel length of 63 mm. and a minimum radius at shoulder of 25 mm. may be used.

Wherever practicable, the wrought surfaces are to be retained on two opposite sides of the test piece.

Straightening of Test Pieces

1618 Any straightening of test pieces which may be required is to be done cold, and the test pieces shall not receive further heat treatment or mechanical working before being tested except by machining to shape.

Chemical Composition

1619 Plates, bars and sections where of non-heat-treatable aluminium alloy are to have the following chemical composition:—

Copper	... not more than		0,10	per cent.	
Magnesium	... ,,	,,	5,5	,,	,,
,,	... ,,	less ,,	3,5	,,	,,
Silicon	... ,,	more ,,	0,6	,,	,,
Iron ...	... ,,	,,	0,5	,,	,,
Manganese	... ,,	,,	1,0	,,	,,
Zinc ...	... ,,	,,	0,2	,,	,,
Chromium	... ,,	,,	0,4	,,	,,
Titanium + Zirconium	,,	,,	0,2	,,	,,
Aluminium	... The remainder.				

1620 Plates, bars and sections of heat-treatable aluminium alloy are to have the following chemical composition:—

Copper	... not more than		0,10	per cent.	
Magnesium	... ,,	,,	1,4	,,	,,
,,	... ,,	less ,,	0,4	,,	,,
Silicon	... ,,	more ,,	1,6	,,	,,
,,	... ,,	less ,,	0,6	,,	,,
Iron ...	... ,,	more ,,	0,5	,,	,,
Manganese	... ,,	,,	1,0	,,	,,
,,	... ,,	less ,,	0,4	,,	,,
Zinc ...	... ,,	more ,,	0,2	,,	,,
Chromium	... ,,	,,	0,3	,,	,,
Titanium + Zirconium	,,	,,	0,2	,,	,,
Aluminium	... The remainder.				

Bars and Sections

1621 May be formed by extrusion, rolling, or by drawing.

Number of Tensile Tests : Plates

1622 Plates from the same cast shall be grouped in thickness for testing as follows:—

25 mm. and over in thickness.
19 mm. and less than 25 mm.
12,5 mm. and less than 19 mm.
4,5 mm. and less than 12,5 mm.

One tensile test is to be taken from each group.

Number of Tensile Tests : Bars and Sections

1623 Sections from the same cast of non-heat-treatable material shall be grouped in weight as follows:—

Less than 1,5 kg. per metre.
Between 1,5 kg. and 13,5 kg. per metre, inclusive.
More than 13,5 kg. per metre.

One tensile test is to be taken from each group.

1624 For sections from the same cast of heat-treatable alloy, the groups will be the heat-treatment batches as defined in P 1612. One tensile test is to be taken from each group.

Tensile Tests : Plates and Sections

1625 The 0,1 per cent proof stress is to be not less than 12,5 kg. per mm.^{2} The tensile breaking strength is to be not less than 27 kg. per mm.^{2}, and the elongation, measured on a gauge length of 200 mm. is to be not less than 10 per cent.

Alternatively, if the elongation is measured on a gauge length of 51 mm. it is to be not less than 12 per cent.

Occasional Attendance at Works

1626 Where the Surveyor is not in constant attendance at the works, the manufacturer may, with the written authority of the Society, comply with all the prescribed requirements and furnish the Surveyor with a certificate to the effect that the Society's Rules for the testing of aluminium alloys for shipbuilding purposes have been complied with in the case of material submitted for approval. The Surveyor is then to examine the works history sheets for the material submitted and, if these are in order, to take check tensile tests from the materials. If the material in a single cast is of uniform thickness, two tensile test pieces are to be selected; if of different thicknesses two tensile test pieces are to be selected from the range of thicknesses presented. The test pieces are to be selected by the Surveyor from the plates or sections themselves, and not from shearings previously detached from them, and, when marked by the

Surveyor for testing, they are to be followed, as far as is practicable, through the different stages of preparation until the tests are completed. If more than one cast is represented each cast is to be tested.

1627 Where the tests are unsatisfactory, the whole of the material from the cast is to be rejected and the Surveyor is to see that the Society's brand is satisfactorily defaced.

Section 17

ALUMINIUM ALLOY RIVET BARS AND MANUFACTURED RIVETS

Testing of Material

1701 All material from which rivets are manufactured is to be tested.

1702 Tensile tests are to be selected in accordance with P 1623 or P 1624.

1703 The 0,1 per cent proof stress is to be not less than 9,5 kg. per mm.^{2} The tensile breaking strength is to be not less than 22 kg. per mm.^{2}, and the elongation is to be not less than 15 per cent if measured on a gauge length of eight times the diameter of the test piece (test piece B) or alternatively, not less than 18 per cent if measured on a gauge length of four times the diameter of the test piece (test piece C).

Dump Test

1704 Test pieces of a length and diameter equal to the full diameter of the bars, preferably cut from the same bars as the tensile tests shall, when cold, withstand being compressed without cracking, until the diameter is increased to 1,6 times the original diameter.

Chemical Composition

1705 Rivet bars and manufactured rivets where of non-heat-treatable aluminium are to have the following chemical composition.:—

Copper	... not more than	0,10	per cent.	
Magnesium	... „ „	4,0	„	„
„	... „ less „	2,8	„	„
Silicon	... „ more „	0,6	„	„
Iron	... ... „ „ „	0,5	„	„
Manganese	... „ „ „	0,6	„	„
Zinc	... ... „ „ „	0,2	„	„
Chromium	... „ „ „	0,4	„	„
Titanium + Zirconium	„ „ „	0,2	„	„
Aluminium	... The remainder.			

1706 Rivet bars and manufactured rivets where of heat-treatable material are to have the chemical composition as laid down in P 1620.

Manufactured Rivets : Heat Treatment and Testing

1707 Rivets of non-heat-treatable alloys are to be supplied in the annealed condition.

Rivets of heat-treatable alloys are to be delivered to the shipyard in the heat-treated condition specified. If, however, suitable facilities are available, then with the concurrence of the rivet manufacturer, the heat treatment may be carried out in the shipyard.

1708 Rivets selected by the Surveyor from bulk are to withstand the tests described in 1709.

1709 Test pieces, cut from the shanks of manufactured rivets, of a length and diameter equal to the full diameter of the shank, shall, when cold, withstand being compressed in an axial direction, without cracking, until the diameter is increased to 1,6 times the original diameter.

Section 18

WELDING OF ALUMINIUM ALLOYS

General

1801 For general requirements where welding is employed, *see* D 3131.

Processes

1802 The following welding processes are to be adopted in the welding of non-heat-treatable aluminium alloys:

Inert gas metal arc welding.

Inert gas tungsten arc welding.

Other processes are to be submitted for approval.

Filler Wire

1803 The chemical composition of filler wire used in welding is to conform to the following requirements:—

Copper	... not more than	0,10	per cent.	
Magnesium	... „ „	5,5	„	„
„	... „ less „	4,5	„	„
Silicon	... „ more „	0,6	„	„
Iron	... ... „ „ „	0,5	„	„
Manganese	... „ „ „	1,0	„	„
Zinc	... ... „ „ „	0,2	„	„
Chromium	... „ „ „	0,4	„	„
Titanium + Zinconium	„ „ „	0,2	„	„
Aluminium	... The remainder.			

Section 19

CAST IRON CRANK SHAFTS

General

1901 Cast iron crank shafts are to be cast at an approved foundry to an approved material specification, and to approved manufacturing and inspection procedures. The inspection procedure will include the approved size, form and location of the test blocks on the crank shaft castings.

Grades of Cast Iron

1902 Any suitable grade of flake graphite, low alloy, acicular or spheroidal or nodular graphite cast iron may be used for crank shafts. The minimum tensile strength of the particular grade of cast iron, corresponding to the section of the crank shaft, is not to be less than that detailed in the approved Specification. (*See* H 628 and H 629, also N 330 and N 331).

Process of Manufacture

1903 The raw materials of a charge such as pig iron, return scrap and scrap steel, are to be specially selected. The melt is to be closely controlled particularly with regard to temperature, time and composition when inoculated irons are being produced. Where such irons are made, the casting temperature and the time between completion of the inoculation and finished pouring of the castings are to be recorded. The records are to be available to the Surveyor at any time.

The Surveyor is to be provided with a statement giving the chemical composition of the material used for each crank shaft or batch of crank shafts.

Heat Treatment

1904 In general, crank shaft castings other than those which are fully annealed, normalised or oil quenched and tempered, are to receive a suitable stress relief heat treatment before machining.

1905 All heat treatments of castings are to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means of temperature control of the furnace charge. Each casting is to be slowly and uniformly heated to the necessary temperature.

1906 Unless otherwise agreed, test blocks are not to be removed from castings until all heat treatments have been completed. Test blocks are to receive the same heat treatment as the castings and are to be removed from castings and cut to provide test pieces by methods which do not impair or modify the characteristics of the materials. Flame cutting is not permitted for the removal of test blocks from a casting or for cutting up test blocks to provide test pieces.

Provision of Test Material

1907 Unless otherwise approved, test material is to be provided by test blocks cast integral with or gated from each crank shaft. The test blocks are to be sufficient in number to allow of retests, if required. The dimensions of test blocks are to be such as to ensure that the material properties are similar to those of the average section of the crank shaft casting.

Dimensions of Test Pieces

1908 The diameter of a tensile test piece is to be as large as practicable. In general, it should not be less than 14 mm. diameter.

A small flat is to be ground on each crank shaft casting and the Brinell hardness determined.

Number of Tests

1909 At least one tensile test piece is to be taken for each crank shaft.

Testing Machines

1910 Tensile tests are to be carried out by competent personnel in an approved machine of adequate capacity. The machine is to be maintained in an efficient and accurate condition and is to be checked and calibrated at suitable intervals agreed by the Society.

Mechanical Properties

1911 The results of the tensile and hardness tests are to comply with the approved specification for the material.

Additional Tests Before Rejection

1912 Where the results of a tensile test do not comply with the specification, two retests are permitted. If the results of both retests are satisfactory the casting is acceptable as regards the tensile test. If either of the retests fails the casting is unacceptable. For castings which were fully heat treated, reheat treatment followed by retesting may be permitted provided the size of the residue of the test block(s) is suitable, and the agreement of the Surveyor is obtained.

Batch Testing

1913 In the case of small shafts which are produced in quantity and are heat treated together, a system of batch testing may be adopted with the agreement of the Surveyor. In these cases, however, not less than two test pieces are required per melt of which one is to represent the first shaft to be cast and the other the last shaft to be cast.

Inspection of Castings

1914 Where surplus material is to be removed from crank shaft castings before despatch, a machining method is to be employed. Flame cutting is not permissible.

Finished castings which have passed test are to be examined by the Surveyor before despatch. The castings are to be in a clean condition so that all surfaces may be examined including those of bores. Castings are to be free from cracks and other detrimental defects. Cast iron crank shafts are not to be repaired by welding and blemishes are not to be plugged with a filler.

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Branding

1915 Every casting, after it has withstood satisfactorily the prescribed tests and inspection, is to be clearly marked by the Surveyor indicating that the casting has complied with the requirements of the Society.

In the event of any casting proving unsound during machining or at any subsequent stage of survey, it is to be rejected notwithstanding any previous certificate of satisfactory test and inspection.

Surface Treatment

1916 Where it is proposed to harden the surfaces of machined pins and/or journals of cast iron crank shafts, details of the process are to be submitted for approval. Before such a process is applied to a crank shaft it is to be demonstrated by procedure tests and to the satisfaction of the Surveyor, that the process is suitably controlled and does not impair the strength or soundness of the material.

APPENDIX

STEEL MANUFACTURERS

The following establishments have complied with the requirements for quality and testing of steel and have been recognised by the Committee.

Firms in Great Britain and Ireland

Allen, Edgar, & Co., Ltd., Imperial Steel Works, Tinsley, Sheffield 9. (*Castings.*)

Allied Ironfounders, Ltd., Larkhall Steel Foundry, Larkhall, Lanarkshire. (*Castings.*)

Alston Foundry Co., Ltd., Nent Force Foundry, Alston, Cumberland. (*Small castings.*)

Andrews Toledo, Ltd., Toledo Steel Works, Neepsend, Sheffield. (*Ingots, billets and bars.*)

Appleby-Frodingham Steel Co., Branch of the United Steel Companies, Ltd., Scunthorpe, Lincs. (*Slabs, blooms, billets, plates, sections, bars and rods.*)

Armstrong Whitworth (Metal Industries), Ltd., Western Road Works, Jarrow. (*Castings and ingots for forging.*)

Atlas Steel Foundry and Engineering Co., Ltd., The, Armadale, West Lothian. (*Castings.*)

Baird, Archibald, & Sons, Ltd., Hamilton, Lanarkshire. (*Castings.*)

Bairds & Scottish Steel, Ltd., Coatbridge, Lanarkshire,

- Northburn Works. (*Ingots, billets, sections and bars.*)
- Waverley Works. (*Sections and bars.*)
- Victoria Works. (*Sections and bars.*)
- Coats Works. (*Sections and bars.*)

Baker, W. A., & Co., Ltd., Westgate Works, Newport, Mon. (*Castings.*)

Baker Perkins, Ltd., Peterborough. (*Small castings.*)

Barrow Steel Works, Ltd., Barrow-in-Furness, Lancashire. (*Billets, bars and sections.*)

Beardmore, William, & Co., Ltd., Parkhead, Glasgow. (*Castings, ingots, forgings, billets and blooms.*)

Blackett, Hutton & Co., Ltd., Cleveland Steel Foundry, Guisborough, Yorkshire. (*Castings.*)

Blair, George, & Co., Ltd., Armond Carr Works, Tow Law, Co. Durham. (*Castings.*)

Bond's Foundry Co., Ltd., Tow Law, Co. Durham. (*Small castings.*)

Bonnington Castings, Ltd., Leith. (*Small castings.*)

British Rolling Mills, Ltd., Brymill Works, Tipton, Staffs. (*Cold drawn bright bars.*)

Briton Ferry Steel Co., Ltd., Briton Ferry, Neath, Glamorgan. (*Billets.*)

Brockhouse Castings, Ltd., Wednesfield, Wolverhampton. (*Small castings.*)

Brown Bayley Steels, Ltd., Sheffield. (*Ingots, forgings and bars.*)

Brown, The David, Gear Industries, Ltd., (Foundry Division), Penistone, Yorks. (*Castings.*)

Brown, Lenox & Co., Ltd., Pontypridd. (*Castings.*)

Brymbo Steel Works, Branch of G.K.N. Steel Co., Ltd., Brymbo, Wrexham, North Wales. (*Electric steel for forging and re-rolling.*)

Catton & Co., Ltd.,

- Yorkshire Steel Foundry, 29, Chadwick Street, Hunslet, Leeds. (*Castings.*)
- Pontefract Lane, Leeds. (*Small castings.*)

Clyde Alloy Steel Co., Ltd.,

- Craigneuk Works, Flemington, Motherwell. (*Castings, forgings, billets and bars.*)
- Hallside Works, Newton, Glasgow. (*Castings and billets.*)

Coghlan Forge & Rolling Mills, Ltd., and Coghlan Bright Steel, Ltd., Hunslet Forge, Leeds. (*Rolling mills for bars; forgings.*)

Colvilles, Ltd.,
Clydebridge Steel Works, Cambuslang, near Glasgow. (*Plates.*)
Dalzell Steel and Iron Works, Motherwell, Lanarkshire. (*Plates, sections, bars and blooms.*)
Glengarnock Steel Works, Glengarnock, Ayrshire. (*Sections and bars.*)
Ravenscraig Works, Ravenscraig, Lanarkshire. (*Ingots, rolled slabs and thin plates.*)
Consett Iron Co., Ltd., Blackhill, Durham.
Consett Iron Co., Ltd., (Jarrow Mill), Blackett Street, Jarrow-on-Tyne. (*Rolling mills for sections and rounds.*)
Crofts (Engineers), Ltd., Thornbury, Bradford. (*Castings.*)
Cruikshank & Co., Ltd., Denny Iron Works, Denny, Stirlingshire. (*Small castings.*)
Darlington Forge, Ltd., Albert Hill, Darlington. (*Castings, ingots and forgings.*)
Darlington & Simpson, Rolling Mills, Ltd., Darlington. (*Rolling mills for small sections and bars.*)
Darwins Ltd., Tinsley, Sheffield. (*Ingots and forgings.*)
Davy & United Roll Foundry, Ltd., Empire Works, Haverton Hill, Billingham, Co. Durham. (*Castings.*)
Dorman, Long (Steel), Ltd.,
Britannia Works, Middlesbrough. (*Rolling mills for sections and bars.*)
Cleveland Works, South Bank, Middlesbrough. (*Sections and bars.*)
Lackenby Works, Middlesbrough. (*Ingots, billets, sections, bars, strips and plates.*)
Redcar Works, Redcar. (*Plates.*)
Doxford & Sunderland Shipbuilding & Engineering Co., Ltd., Wolsingham Steelworks, Wolsingham, Bishop Auckland, Co. Durham. (*Castings and forgings.*)
English Steel Casting Corporation, Ltd., Grimesthorpe Works, Sheffield. (*Ingots and castings.*)
English Steel Forge & Engineering Corporation, Ltd.,
English Steel Rolling Mills Corporation, Ltd.,
North St. Works, Openshaw, Manchester. (*Forgings, bars, plates up to ½ inch in thickness.*)
River Don Works, Sheffield. (*Forgings, plates, ingots, billets and bars.*)
Tinsley Park Works, Sheffield. (*Ingots, blooms, billets, slabs and bars.*)
Etna Iron and Steel Co., Ltd., Motherwell, Lanarkshire. (*Rolling mills for sections and bars.*)
Firth Brown, Ltd.,
Atlas Works, Sheffield. (*Ingots, forgings, rolled bars and billets.*)
Scunthorpe Works, Scunthorpe, Lincs. (*Castings.*)
Firth Vickers Stainless Steels, Ltd., Blackheath Foundry, Birmingham. (*Castings.*)
Sheffield Works, Sheffield. (*Rolling mills for plates, bars and sections; also castings.*)
Fox, Samuel, & Co., Ltd., Stocksbridge Works, near Sheffield. (*Ingots.*)
Glanmorfa, Ltd., Llanelly. (*Castings.*)
Guest, Keen & Nettlefolds (South Wales), Ltd., Cardiff.
Castle Works. (*Rolling mills for bars and strips.*)
Tremorfa Works. (*Rolling mills for bars and sections.*)
Guest Keen Iron & Steel Co., Ltd., East Moors, Cardiff. (*Ingots, blooms and billets; sections and bars.*)
Hadfields, Ltd., East Hecla Works, Sheffield. (*Ingots, blooms, billets, forgings, bars, special sections and castings.*)
Halesowen Steel Co., Ltd., The, Halesowen, near Birmingham. (*Cold drawn bright bars.*)
Hamilton, A., & Sons, Ltd., Victoria Foundry, East Moors, Cardiff. (*Small castings.*)
Head, Wrightson Steel Foundries, Ltd.,
Light Pipe Hall Road, Stockton-on-Tees. (*Castings.*)
Teesdale Iron Works, Thornaby-on-Tees. (*Castings.*)
Hopkinsons, Ltd., Britannia Works, Huddersfield, Yorkshire. (*Castings.*)
Hyde, Robert & Son, Ltd.,
Clarendon Works, Chesterfield. (*Small castings.*)
North Stafford Steel Works, Stoke-on-Trent. (*Small castings.*)
Jessop-Saville, Ltd., Brightside Works, Sheffield. (*Ingots, blooms, bars, forgings and castings.*)
Jopling, E., & Sons, Ltd., Pallion, Sunderland. (*Castings.*)
K. & L. Steelfounders & Engineers Limited, Letchworth, Hertfordshire. (*Castings.*)

Kirkstall Forge Engineering, Ltd., Leeds. (*Rolling mills for bars, forgings and heavy drop forgings.*)
Lake & Elliot, Ltd., Engineers and Founders, Braintree, Essex. (*Small castings.*)
Lanarkshire Steel Co., Ltd., Motherwell, Lanarkshire. (*Sections.*)
Lancashire Steel Manufacturing Co., Ltd.,
Irlam, Manchester. (*Billets, bars, sections and castings.*)
Pearson & Knowles Works, Warrington, Lancs. (*Rolling mills for sections and bars.*)
Lilleshall Co., Ltd., St. George's, near Oakengates, Shropshire. (*Rolling mills for sections and bars.*)
Llanelly Steel Co. Ltd., Llanelly Steel Works, Llanelly. (*Billets and bars.*)
Lloyd, F. H., & Co., Ltd.,
James Bridge, near Wednesbury, Staffordshire. (*Ingots and castings.*)
Cardiff Works, Curran Road, Cardiff. (*Ingots and castings.*)
Lloyds (Burton) Ltd., Wellington Works, Burton upon Trent, Derbyshire. (*Ingots and castings.*)
Lysaght's Scunthorpe Works, Branch of G.K.N. Steel Co., Ltd., Scunthorpe, Lincs. (*Ingots, billets, slabs and bars.*)
Martins (Dundyvan), Ltd., Coatbridge, Lanarkshire. (*Rolling mills for sections.*)
Mills, Exors. of James, Ltd., Bredbury Steel Works & Rolling Mills, near Stockport. (*Rolling mills for bars.*)
Monks, Hall & Co., Ltd., Warrington. (*Rolling mills for bars.*)
National Steel Foundry (1914), Ltd., The, Kirkland Works, Leven, Fifeshire. (*Castings.*)
North British Steel Foundry, Ltd., The, Balbardie Steel Works, Bathgate. (*Castings.*)
Osborn, Samuel, & Co., Ltd., Clyde Steel Works, Sheffield. (*Castings.*)
Park Gate Iron & Steel Co., Ltd.,
Park Gate Works, Rotherham. (*Rolled sections, bars & billets.*)
Aldwarke Works, Rotherham. (*Ingots, billets, bars & strip.*)
Parker Foundry (1929) Ltd., Mansfield Road, Derby. (*Small castings.*)
Patent Shaft Steel Works, Ltd., Wednesbury, Staffordshire.
Porterfield Foundries Ltd., Renfrew. (*Small castings.*)
Raine & Co., Ltd., Delta Iron & Steel Works, Derwenthaugh, Newcastle upon Tyne. (*Rolling mills for sections and bars.*)
Redheugh Iron & Steel Co. (1936), Ltd., Teams, Gateshead-on-Tyne. (*Rolling mills.*)
Renton & Fisher, Ltd., Hopetoun Steel Works, Bathgate. (*Castings.*)
Robertson, Wm., Ltd., Latchford, Warrington. (*Cold drawn bright bars.*)
Round Oak Steel Works, Ltd., Brierley Hill, Staffordshire. (*Ingots, blooms, billets, bars and sections.*)
Ryder Brothers, Ltd. (Beehive Steel Foundry), Bolton. (*Small castings.*)
Sanderson Brothers & Newbould Limited, Sheffield. (*Ingots, billets and bars.*)
Shaw, W., & Co., Ltd., Wellington Cast Steel Foundry, Middlesbrough. (*Castings.*)
Shelton Iron & Steel, Ltd., Stoke-on-Trent. (*Ingots, billets, bars and sections.*)
Skinningrove Iron Co., Ltd., Skinningrove Iron Works, Saltburn-by-the-Sea. (*Sections and bars.*)
South Durham Steel & Iron Co., Ltd.,
West Hartlepool. (*Plates.*)
Cargo Fleet Ironworks, Middlesbrough. (*Sections and bars.*)
Spartan Steel and Alloys Ltd., Spartan Works, Birmingham 6. (*Ingots.*)
Spear & Jackson, Ltd., Sheffield. (*Ingots and billets.*)
Steel Company of Wales, Ltd., Abbey Works, Port Talbot. (*Ingots, plates and strips.*)
Steel, Peech & Tozer, Rotherham, Branch of The United Steel Companies Ltd. (*Ingots, blooms, forgings, rivet and stay bars.*)
Stewarts & Lloyds, Ltd.,
Bilston Iron & Steel Works, Bilston, Staffordshire. (*Tube ingots, billets and bars.*)
Clydesdale Steel and Tube Works, Bellshill, Lanarkshire. (*Ingots, billets, slabs and strips for tubes.*)
Corby Works, Corby, Northants. (*Ingots, billets, slabs and strips.*)
Tollcross Foundry, Tollcross, Glasgow. (*Castings.*)

Summers, John, & Sons Ltd., Hawarden Bridge Steel Works, Shotton, Chester. (*Ingots, slabs and light plates.*)
Summersons Foundries. Ltd., Darlington. (*Small castings.*)
Taylor Bros. & Co., Ltd., Trafford Park Steel Works, Manchester. (*Ingots.*)
Thomas, Richard, & Baldwins Ltd.,
Ebbw Vale Works, Ebbw Vale, Monmouthshire. (*Ingots.*)
Redbourne Works, Scunthorpe. (*Ingots, billets, bars and slabs.*)
Spencer Works, Llanwern, near Newport, Monmouthshire. (*Light plates.*)
Vickers Ltd., Engineering Group, Vickers-Armstrongs, Barrow Engineering Works, Barrow-in-Furness. (*Castings and forgings.*)
Washington Steel Foundries, Ltd., Washington Station S.O., Co. Durham. (*Castings.*)
Whitehead Iron & Steel Co., Ltd., Courtybella Works, Newport, Mon. (*Rolling mills for strips, bars and sections.*)
Whitehead, Thomas, Bar and Strip Co., Ltd., Redbourne Works, Scunthorpe, Lincs. (*Rolling mills for bars and strips.*)
Williams, John, (Wishaw), Ltd., Excelsior Iron & Steel Works, Wishaw, Lanarkshire. (*Rolling mills for thin plates.*)
Wilson's Foundry & Engineering Co., Ltd., Bishop Auckland, Co. Durham. (*Castings.*)
Workington Iron & Steel Co., Workington, Cumberland. (*Ingots, blooms, billets, slabs and bars for manufacture of small forgings (Acid Bessemer or electric steel); rolled sections (electric steel only).*)

Irish Republic.
Irish Steel Holdings Ltd., Haulbowline, Co. Cork. (*Ingots, bars and sections.*)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND (ALPHABETICALLY ARRANGED)

Note: The place of residence of the Surveyor giving attendance at each works is shown in parentheses.

A.1. Iron & Steel Foundry, Ltd., Vancouver, B.C. (*Small castings.*) (VANCOUVER.)

A.S.S.A. Acciaierie di Susa Società Anonima, Turin, Italy. *Head Office:* Turin. *Works:* Susa. (*Castings.*) (GENOA.)

Acerias y Forjas de Azciotia, Azciotia Juipuzcoa, Spain, (*Ingots and small rolled bars.*) (BILBAO.)

Aceros y Fundiciones del Norte Pedro Orbegozo y Cia. S.A., Hernani, (Guipuzcoa), Spain. (*Ingots and forgings*). (BILBAO.)

Aceros de Galicia, Vigo, Spain. (*Castings.*) (GIJON.)

Aceros del Zarzo S.A. (Adeza), Cabanas, Puentedeume (La Coruna), Spain. (*Ingots and small castings.*) (EL FERROL.)

Aciéries du Furan, St. Etienne (Loire), France. (*Electric steel castings.*) (MARSEILLES.)

"Acieroy", Aciéries et Fonderies du Doubs, Société Anonyme, Sainte-Suzanne, near Montbéliard (Doubs), France. (*Small electric steel castings.*) (PARIS.)

Acos Villares S.A. Sao Caetano do Sul, Sao Paulo, Brazil. (*Castings, forgings, billets and bars.*) (RIO DE JANEIRO.)

Ahlström, A., Oy, Karhulan Tehtaat, Karhula Bruk, Karhula, Finland. (*Castings.*) (HELSINGFORS.)

Aichi Steel Works, Ltd.
- Chita Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*) (KOBE.)
- Kariya Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*) (KOBE.)

Alco Products, Inc., Latrobe, Pa., U.S.A. (*Ingots and forgings.*) (CLEVELAND, O.)

Algoma Steel Corporation, Ltd., Sault St. Marie, Ontario, Canada. (*Billets, bars, angles and plates.*) (TORONTO.)

Allard, Usines & Aciéries, Société Anonyme, Mont-sur-Marchienne, near Charleroi, Belgium. (*Castings.*) (ANTWERP.)

Allard, Usines & Aciéries, Société Anonyme, Turnhout, Belgium. (*Small castings.*) (ANTWERP.)

Altos Hornos de Mexico, S.A., (A.H.M.S.A.), Monclova, Coah., Mexico. (*Plates.*) (TAMPICO.)

American Rolling Mill Co., Middletown, O., U.S.A. (*Castings and forgings.*) (CLEVELAND, O.)

Amsco Italiana S.p.A., Milan, Italy. (*Small castings.*) (MILAN.)

Amurrio, S.A., Talleres de., Amurrio, Alava, Spain. (*Steel castings.*) (BILBAO.)

Anderson, Aktiebolaget Abjörn, Svedala, near Malmö, Sweden. (*Castings.*) (MALMÖ.)

Ando Iron Works Co., Ltd., Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Ansaldo S.p.A., Stabilimento Fonderia di Ghisa e Metalli, Genova-Pegli, Italy. (*Forgings.*) (GENOA.)

"ARBED", Aciéries Réunies de Burbach-eich-Dudelange,
- Division de Dommeldange, Dommeldange, Luxembourg. (*Ingots, forgings and castings.*) (SAARBRÜCKEN.)
- Division de Belval, Esch-sur-Allzette, Luxembourg. (*Ingots, blooms, billets, bars and angle bars.*) (SAARBRÜCKEN.)
- Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*) (SAARBRÜCKEN.)
- Division de Burbach, Sarrebruck,
  - Burbach Works. (*Ingots, billets and sections.*) (SAARBRÜCKEN-SAAR.)
  - Hostenbach Works. (*Plates.*) (SAARBRÜCKEN-SAAR.)

Astilleros Rio Santiago Ensenada, Buenos Aires, Argentina. (*Steel castings.*) (BUENOS AIRES.)

Astilleros y Talleres del Noroeste S.A., El Ferrol del Caudillo, Spain. (*Small forgings and small castings.*) (EL FERROL.)

Atlantic Steel Castings Co., The, Chester, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Atlas Steels Company, Welland, Ontario, Canada. (*Ingots and bars.*) (TORONTO.)

Aubert et Duval, Anciens Ets., Aciéries des Ancizes, Puy de Dome, France. (*Ingots, rolled bars and forgings.*) (MARSEILLES.)

August Thyssen-Hütte, A.G., Duisburg-Hamborn, Germany. (*Ingots, billets, sections, bars and thin plates.*) (DUSSELDORF.)

Australian Iron & Steel, Pty., Ltd., Port Kembla, N.S.W. (*Plates, bars, sections and forgings.*) (PORT KEMBLA.)

d'Auxonne, Acieries & Fonderies, Auxonne (Côte d'Or), France. (*Small castings.*) (PARIS.)

Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Plates, sections and castings; also high pressure air receivers.*) (STOCKHOLM.)

Azuma Steel Works, Ltd.
- Azuma Plant, Tokyo, Japan. (*Ingots for plate.*) (YOKOHAMA.)
- Senju Plant, Tokyo, Japan. (*Rolling mills for plates.*) (YOKOHAMA.)

Babcock & Wilcox, Sociedad Espanola de Construcciones.
Head Office: Calle Ercilla 1, Bilbao, Spain.
Works: Galindo-San Salvador Del Valle, Vizcaya, Spain. (*Castings, ingots and forgings.*) (BILBAO.)

Bakker, N.V., Machinefabriek-Staalgieterij, Ridderkerk, Holland. (*Ingots and castings.*) (ROTTERDAM.)

Basconia, Compañia Anonima, Bilbao, Spain. (*Plates, sections and bars.*) (BILBAO.)

Bergische Stahlindustrie K.G., Remscheid, Germany. (*Castings.*) (DUSSELDORF.)

Bertoli fu Rodolfo, S.p.A., Officine Fratelli, Udine, Italy. (*Castings, forgings, bars and sections.*) (TRIESTE.)

Bethlehem Steel Co.,

Bethlehem, Pa., U.S.A. (*Ingots, forgings, bars and sections.*) (PHILADELPHIA.)

Burns Harbour Plant, Chesterton, Indiana, U.S.A. (*Rolling mills for plates.*) (CHICAGO.)

Johnstown Plant, Johnstown, Pa., U.S.A. (CLEVELAND.)

Lackawanna, N.Y., U.S.A. (CLEVELAND, O.)

Lebanon, Pa., U.S.A. (*Rolling mills for bars.*) (PHILADELPHIA.)

Los Angeles 54, Cal., U.S.A. (*Round bars.*) (LOS ANGELES.)

Seattle, Wash., U.S.A. (*Sections and bars.*) (SEATTLE.)

Sparrows Point, Md., U.S.A. (*Plates.*) (BALTIMORE.)

Steelton, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Bhartia Electric Steel Co., Ltd., Calcutta, India. (*Castings.*) (CALCUTTA).

Birdsboro Corporation, Birdsboro, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Ingots and forgings*). (GOTHENBURG.)

Blanc-Misseron, Société Française des Aciéries de, Quievrechain, Nord, France. (*Ingots and castings.*) (VALENCIENNES.)

Boel, Usines Gustave, Soc. An., La Louvière, Belgium. (*Ingots, forgings, castings, plates and bars.*) (ANTWERP.)

Bofors, Aktiebolaget, Bofors, Sweden. (*Ingots, forgings, castings and rolled bars.*) (GOTHENBURG.)

Böhler, Gebr. & Co., Aktiengesellschaft, Vienna, Austria.

Works: Kapfenberg, Styria. (*Ingots, castings, forgings, bars and plates.*) (VIENNA.)

Works: Bruckbach, Low Austria. (*Rolling mills for sections and bars.*) (VIENNA.)

Bolzano, S.p.A. Acciaierie di, Bolzano, Italy. (*Ingots, billets, bars and forgings.*) (VENICE.)

Boom, Travaux Métalliques de, Société Anonyme, Boom, Belgium. (*Small castings.*) (ANTWERP.)

Borsig A.G., Berlin-Tegel, Germany. (*Ingots, forgings and castings.*) (BERLIN.)

Boxholms A/B., Boxholm, Sweden. (*Ingots, rolled slabs, blooms, billets, sections and bars.*) (STOCKHOLM.)

Bradford Kendall Ltd.

Works: Adelaide, South Australia. (*Castings.*) (ADELAIDE.)

Works: Alexandria, Sydney, N.S.W. (*Castings.*) (SYDNEY, N.S.W.)

Works: Runcorn, Queensland. (*Castings.*) (BRISBANE.)

Brasileira de Usinas Metalurgicas, The Companhia, Usina de Neves, Sao Goncalo, Estado do Rio de Janeiro, Brazil. (*Ingots, sections and bars.*) (RIO DE JANEIRO.)

Breda Fucine S.p.A., Sesto San Giovanni, Milan, Italy. (*Castings and forgings.*) (MILAN.)

Breda Siderurgica Società per Azioni, Sesto San Giovanni, Milan, Italy. (*Ingots and sections.*) (MILAN.)

Breitenbach, Ed., G.m.b.H., Weidenau-Sieg, Germany. (*Castings.*) (COLOGNE.)

Brescia, Acciaieria e Tubificio di, Società Anonima, Brescia, Italy. (*Ingots, sections and bars, castings, weldless drawn or water gas welded tubular material.*) (MILAN.)

Broken Hill Proprietary Co., Ltd.

Rolling Mill, Kwinana, W. Australia. (*Small bars and sections.*) (FREMANTLE.)

Iron & Steel Works, Newcastle, N.S.W. (*Ingots, billets, plates, sections, strip and castings.*) (NEWCASTLE, N.S.W.)

Steel Foundry and Rolling Mill, Whyalla, S. Australia. (*Ingots, castings, bars and sections.*) (WHYALLA.)

Burlington Steel Company, Division of States Steel Industries, Ltd., Hamilton, Ontario, Canada. (*Small sections and bars.*) (TORONTO.)

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Ingots, forgings and castings.*) (COPENHAGEN.)

Burn & Co., Ltd., Howrah, India. (*Castings.*) (CALCUTTA.)

Caleotto, Acciaieria e Ferriera del, S.p.A., Lecco, Italy. (*Ingots, castings, bars, small sections and small forgings.*) (MILAN.)

Canada Foundries & Forging, Ltd., Welland, Ontario, Canada. (*Forgings.*) (TORONTO.)

Canadian Steel Foundries Division Hawker Siddeley Canada Ltd., Longue Pointe, Montreal, P.Q., Canada. (*Castings.*) (MONTREAL.)

Canadian Sumner Iron Works Ltd., Vancouver, B.C. (*Small castings.*) (VANCOUVER.)

Canadian Unitcast-Steel, Ltd., Sherbrooke, P.Q., Canada. (*Castings.*) (MONTREAL.)

Cantieri Del Tirreno, S.p.A., Riva Trigoso, Genoa, Italy. (*Small forgings.*) (GENOA.)

Cantieri Navali Riuniti. *Head Office* : Genoa. *Works:* Cantiere Navale ed Officine Meccaniche di Ancona. (*Small castings.*) (MILAN.)

Ceretti, Pietro Maria, S.p.A., Ferriera Dell'Ossola-Villadossola, Italy. (*Castings.*) (MILAN.)

Charleroi, Société Anonyme de la Fabrique de Fer de, Charleroi, Belgium. (*Ingots, slabs and plates.*) (ANTWERP.)

Chiers, Société des Hauts-Forneaux de la, Forges de Vireux Molhain, Vireux, Ardennes, France. (*Plates, sections and bars.*) (VALENCIENNES.)

Christiania Spigerverk, Oslo, Norway. (*Ingots and bars, also rivet bars.*) (OSLO.)

Chubu Steel Plate Co. Ltd., Nakagawa Works, Nagoya, Japan. (*Ingots and plates.*) (KOBE.)

Clabecq, Société Anonyme Forges de, Clabecq, Belgium. (*Ingots, plates, bars and sections.*) (ANTWERP.)

Cockerill-Ougrée, Société Anonyme, Seraing, Belgium.
Works: Division Centre. (*Ingots, blooms, billets, slabs and plates.*) (ANTWERP.)
Works: Division Ouest. (*Ingots, blooms, billets, plates, sections, castings and forgings.*) (ANTWERP.)

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A. (*Ingots, bars and small sections.*) (CHICAGO.)

"COMETNA" Companhia Metalurgica Nacional, S.A.R.L., Amadora, Portugal. (*Castings.*) (LISBON.)

Commonwealth Steel Co., Ltd., Waratah, Newcastle, N.S.W. (*Castings and forgings.*) (NEWCASTLE, N.S.W.)

Compagnie des Ateliers et Forges de la Loire.
Usine des Dunes, Malo les Bains (Nord), France. (*Ingots, billets, blooms, bars and forgings.*) (VALENCIENNES.)
Usines de l'Ondaine, Firmigny (Loire), France. (*Ingots, billets, blooms, bars, castings and forgings.*) (MARSEILLES.)
Usines de l'Ondaine, Unieux (Loire), France. (*Forgings.*) (MARSEILLES.)
Usines de St. Chamond, St. Chamond (Loire), France. (*Forgings and plates.*) (MARSEILLES.)
Usines de St. Etienne, St. Etienne (Loire), France. (*Plates.*) (LYONS.)

Compagnie Générale des Aciers, Société Anonyme, Thy-le-Château, Belgium. (*Castings.*) (ANTWERP.)

Companhia Siderurgica Nacional, Volta Redonda, Usina Presidente Vargas, Estado do Rio de Janeiro, Brazil. (*Plates and sections.*) (RIO DE JANEIRO.)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small castings and forgings.*) (BILBAO.)

Consolidated Mining & Smelting Co. of Canada Ltd., Trail, B.C., Canada. (*Castings.*) (VANCOUVER.)

Crane-Fisa S.A., Bilbao, Spain. (*Small castings.*) (BILBAO.)

Crane-Orion S.p.A., Porto Industriale, Trieste, Italy. (*Forgings and castings.*) (TRIESTE.)

Creusot, Société des Forges et Ateliers du, (S.F.A.C.), Usines Schneider, Le Creusot, France. (*Ingots, forgings, castings, plates and sections.*) (PARIS.)

Crucible Steel Company of America, 4, Gateway Center, P.O. Box 88, Pittsburgh 30, Pa., U.S.A.
Midland Plant, Midland, Pa. (*Ingots, slabs, billets, universal mill plates, hot rolled and cold drawn bars.*) (CLEVELAND, O.)

Crucible Steel Company of Canada, Ltd., Sorel, P.Q., Canada. (*Castings.*) (MONTREAL.)

Daido Steel Co., Ltd.
Chita Plant, Nagoya, Aichi Prefecture, Japan. (*Ingots, billets and bars.*) (KOBE.)
Hoshizaki Works, Nagoya, Japan. (*Ingots and bars.*) (KOBE.)
Shibukawa Works, Shibukawa, Japan. (*Ingots, small forgings and bars.*) (YOKOHAMA.)
Tsukiji Works, Nagoya, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Daitetsu Steel Industrial Co. Ltd., Osaka, Japan. (*Ingots and sections.*)

Dalmine S.p.A. *Head Office:* Milan, Italy.
Dalmine Costa Volpino, Bergamo. (*Seamless tubes.*) (MILAN.)
Dalmine Works, Bergamo. (*Ingots and seamless tubes.*) (MILAN.)

Danske, (Det), Staalvalsevaerk A/S, Frederiksvaerk, Denmark. (*Plates, sections and bars.*) (COPENHAGEN.)

Date Seiko Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Davies & Baird Pty. Ltd., 227, Brunswick Road, Brunswick, Melbourne 10, Australia. (*Castings.*) (MELBOURNE.)

De Wendel et Cie., S/A., Hayange, Moselle, France.
Usine de Fenderié. (*Plates.*) (SAAR.)
Usine de St. Jacques. (*Sections.*) (SAAR.)

Decker, Gebrüder, Betrieb 1, Eisen- & Stahlgiesserei, Nürnberg 2, Ostendstr. 84. (*Electric steel castings.*) (AUGSBURG.)

Dembiermont & Cie., Maurice, Hautmont (Nord), France. (*Forgings.*) (VALENCIENNES.)

Deusto, S.A., Talleres de, Luchana, Bilbao, Spain. (*Ingots, castings and small forgings.*) (BILBAO.)

Deutsche Edelstahlwerke A.G., Krefeld, Germany. (*Ingots, castings, forgings and rolled materials.*) (DUSSELDORF.)

Deutsche Gerätebau G.m.b.H., Werk Stahl u., Eisengiesserei Schubeis, Schwelm, Germany. (*Castings.*) (DORTMUND.)

Dikkers, G., & Co., N.V., Hengelo, Holland. (*Small castings.*) (AMSTERDAM.)

Dingler, Karcher & Cie., G.m.b.H., Saarbrücken-Saar. (*Castings.*) (SAARBRÜCKEN-SAAR.)

Dingler, Karcher & Cie., G.m.b.H., Saarländisches Stahlwerk, Worms/Rhein, Germany. (*Castings.*) (MANNHEIM.)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Dominion Foundries & Steel Ltd., Hamilton, Ontario, Canada. (*Ingots, plates and castings.*) (TORONTO.)

Dominion Steel & Coal Corporation Ltd.
Montreal Works, 5870, St. Patrick Street, Montreal, Canada. (*Angles, bars and rivets.*) (MONTREAL.)

Donegal Steel Foundry Company, 601, East Market Street, Marietta, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Dosco Steel Ltd., Sydney Works, Sydney, N.S., Canada. (*Ingots, billets and sections.*) (HALIFAX, N.S.)

Drammens Jernstoberi & Mek-Verksted, A/S, Drammen, Norway. (*Small castings.*) (OSLO.)

Dunswart Iron & Steel Works, Ltd., Benoni, South Africa. (*Castings, ingots, billets and small sections.*) (VEREENIGING.)

Duro-Felguera, Sociedad Metalúrgica, La Felguera, Asturias, Spain. (*Castings.*) (GIJON.)

Echevarria, Sociedad Anonima, Bilbao, Spain. (*Small sections and bars, small forgings and ingots.*) (BILBAO.)

Echeverria, Patricio, S.A., Legazpia, Spain. (*Ingots, blooms, forgings and small bars.*) (BILBAO.)

Edelstahlwerk Witten A.G., Witten-Ruhr, Germany. (*Ingots, billets, sections, bars and forgings.*) (DORTMUND.)

Egyptian Iron & Steel Co., S.A.E., Helwan, U.A.R. (*Plates.*) (PORT SAID.)

Eisen-und Stahlwerk Pleissner G.m.b.H., Herzberg/Harz, Germany. (*Castings.*) (HANNOVER.)

Eisenwerk Geweke, R. & C. R. Lange K.G., Hagen-Haspe, Germany. (*Electric steel castings.*) (DORTMUND.)

Eisenwerk Rödinghausen K.G., Lendringsen Krs., Iserlohn, Germany. (*Castings.*) (DORTMUND.)

"ELCANO", Empresa Nacional, Factoria de Manises, Valencia, Spain. (*Castings and forgings.*) (VALENCIA.)

Electrodos y Aceros S.A., Boö, Santander, Spain. (*Castings.*) (BILBAO.)

Ellerbrock, Hans, Stahlgiesserei und Maschinenfabrik, Hamburg, Germany. (*Castings.*) (HAMBURG.)

Empire Steel Castings Inc., Reading, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Empresa Nacional Bazan, El Ferrol del Caudillo, Spain. (*Castings.*) (EL FERROL.)

Empresa Nacional Siderurgica, S.A., (ENSIDESA), Avilés, Spain. (*Ingots, slabs and billets for re-rolling, plates and sections.*) (GIJON.)

Endo Iron Works Co. Ltd., Osaka, Japan. (*Forgings.*) (KOBE.)

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Erie Forge Co., Erie, Pa., U.S.A. (*Ingots, forgings and castings.*) (CLEVELAND, O.)

Eschweiler Bergwerks-Verein Hüttenbetriebe, Eschweiler-Aue, Germany. (*Ingots and seamless tubes.*) (COLOGNE.)

Esco Ltd., Port Coquitlam, B.C., Canada. (*Castings.*) (VANCOUVER.)

Española de Construccion Naval, Sociedad.
- Reinosa, near Santander, Spain. (*Ingots, forgings, castings, plates and sections.*) (BILBAO.)
- Sestao, near Bilbao, Spain. (*Small castings, ingots and forgings.*) (BILBAO.)
- San Carlos Factory, San Fernando, Cadiz, Spain. (*Forgings and castings.*) (CADIZ.)

Esperance Longdoz S.A., Liege, Belgium. (*Ingots and thin plates.*) (ANTWERP.)

Euskalduna, Compania, Funicion de Asua, (near Bilbao,) Vizcaya, Spain. (*Castings.*) (BILBAO.)

F.A.S.E.F., S.p.A., Fonderie Acciaio Scabar e Figli, Porto Industriale, Trieste, Italy. (*Small castings.*) (TRIESTE).

Fabrica Italiana Tubi, Società per Azioni, Sestri-Levante, Italy. (*Ingots, billets and weldless rolled and drawn tubes.*) (GENOA.)

Fabricaciones Metalurgicas, S.A., "Famesa", Arrancudiaga, Vizcaya, Spain. (*Ingots and rolled bars.*) (BILBAO.)

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Brukskoncernen).
- *Works :* Fagersta. (*Blooms, billets, forgings, rolled bars and electric resistance welded tubes.*) (STOCKHOLM.)
- *Works :* Forsbacka. (*Blooms, billets, forged and rolled bars.*) (STOCKHOLM.)
- *Works :* Horndal. (*Bars and sections.*) (STOCKHOLM.)
- *Works :* Osterbybruk. (*Castings, forgings and rolling mill for bars.*) (STOCKHOLM.)

Faggian, Acciaierie Elettriche Pio, Soc. per Azioni, La Spezia, Italy. (*Small castings.*) (LA SPEZIA.)

Falck, Acciaierie e Ferriere Lombarde. *Head Office & Works :* Milan, Italy. (*Weldless rolled or drawn tubes.*) (MILAN.)
- "Concordia". *Works:* Sesto San Giovanni. (*Ingots and plates.*) (MILAN.)
- "Unione". *Works :* Sesto San Giovanni. (*Ingots, sections, bars, forgings and castings.*) (MILAN.)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Castings.*) (CHICAGO.)

Ferry-Capitain & Cie., Société, Bussy, près Joinville, Haute-Marne, France. (*Electric steel castings.*) (PARIS.)

Feurs, Fonderies & Acieries Electriques de, Feurs, Loire, France. (*Small castings.*) (MARSEILLES.)

FIAT, Società per Azioni, Sezione Ferriere Piemontesi, Turin, Italy. (*Ingots, plates, sections, also seamless and welded tubes.*) (GENOA.)

FIAT, Società per Azioni, Sezione Industrie Metallurgiche Acciaierie, Turin, Italy. (*Castings.*) (GENOA.)

Finkl, A., & Sons Company, Chicago, Ill., U.S.A. (*Forgings.*) (CHICAGO.)

Fischer, George, Ltd., Schaffhausen, Switzerland. (*Castings.*) (WINTERTHUR.)

Fives-Lille-Cail, Société de.
- Usine de Fives, Lille (Nord), France. (*Forgings.*) (VALENCIENNES.)
- Usine de Denain, Denain (Nord), France. (*Castings, ingots, forgings, blooms, bars and sheets.*) (VALENCIENNES.)

Flag S.p.A. Marcon (Mestre). (*Small castings.*) (VENICE.)

Fonderia Acciaieria Giovanni Mandelli, Turin, Italy. (*Castings.*) (GENOA.)

Fonderie de fer et d'Acier, Biel, Switzerland. (*Castings.*) (WINTERTHUR.)

Forjas Alavesas S.A., Vitoria, Spain. (*Ingots, rolled bars and forgings.*) (BILBAO.)

Frichs A/S, Aarhus, Denmark. (*Castings.*) (COPENHAGEN.)

Fried. Krupp Hüttenwerke A.G., Gussstahlwerk Bochumer Verein, Bochum, Germany. (*Ingots, forgings, castings and bars.*) (DUSSELDORF.)

Fried. Krupp Hüttenwerke A.G. Huttenwerke Rheinhausen, Rheinhausen, Germany. (*Bars and sections only.*) (DUSSELDORF.)

Friedrich-Carl-Hütte G.m.b.H., Delligsen über Alfeld/Leine, Germany. (*Castings.*) (HANNOVER.)

Fuji Iron & Steel Co., Ltd.

Works : Hirohata, Himeji City, Japan. (*Ingots, billets, plates and sections.*) (KOBE.)

Works : Kamaishi, Japan. (*Sections and bars.*) (YOKOHAMA.)

Works : Kawasaki, Japan. (*Rolling mills for strips for electric resistance welded tubes.*) (YOKOHAMA.)

Works : Muroran, Hokkaido, Japan. (*Billets, sections and bars.*) (YOKOHAMA.)

Fujinagata Shipbuilding & Engineering Co., Ltd., Osaka, Japan. (*Forgings.*) (KOBE.)

Fukushima Seiko Co., Ltd., Fukushima, Japan. (*Castings.*) (YOKOHAMA.)

Funderia, S.A. de, Manresa, Spain. (*Castings.*) (BARCELONA.)

Fundiciones Echevarria S.A., Beasain, Guipuzcoa, Spain. (*Ingots, small rolled bars and castings.*) (BILBAO.)

Fundiciones Escorsa S.A., Pi y Margall, 2- Hospitalet de Llobregat, Barcelona, Spain. (*Castings.*) (BARCELONA.)

Fundidora de Fierro y Acero de Monterrey, S.A., Monterrey, N.L., Mexico. (*Plates.*) (TAMPICO.)

Ganz-Mavag Mozdony Vagon es Gepgyar, Budapest, Hungary. (*Castings and forgings.*) (VIENNA.)

General Metals Corporation, Oakland, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Gennevilliers, Aciéries de, Gennevilliers, Seine, France. (*Castings.*) (PARIS.)

Go Iron Works, Ltd., Tarui Works, Tarui, Japan. (*Small castings.*) (KOBE.)

Gorizia, S.A. Fonderie Officine di, Gorizia, Italy. (*Small castings.*) (TRIESTE.)

Granite City Steel Co., Granite City, Ill., U.S.A. (CHICAGO.)

Great Lakes Steel Corporation, Division of National Steel Corporation, Ecorse, Detroit 29, Michigan, U.S.A. (*Ingots, billets, bars, slabs, plate, blooms, sheet and coiled strip.*) (CLEVELAND.)

Gresele, Acciaierie Valbruna di Ernesto, Vicenza, Italy. (*Castings, bars, sections and forgings.*) (VENICE.)

Guérigny, Forges Nationales de la Chaussade à Nievre, France. (*Ingots, bars, forgings and castings.*) (PARIS.)

Gueugnon, Forges de, Gueugnon, (S & L), France. (*Rolling mill for plates.*) (PARIS.)

Gussstahlwerk Carl Bönnhoff, Wetter/Ruhr, Germany. (*Castings.*) (DORTMUND.)

Gussstahlwerk Oberkassel A.G., Düsseldorf-Oberkassel, Germany. (*Castings.*) (DUSSELDORF.)

Gussstahlwerk Risch K.G., Bergisch-Gladbach, Germany. (*Electric steel castings.*) (COLOGNE.)

Gussstahlwerk Wittman A.G., Hagen-Haspe, Germany. (*Castings.*) (DORTMUND.)

Gutehoffnungshütte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade, Germany. (*Forgings.*) (DUSSELDORF.)

Hachette & Driout, S.A. des Anciens Etablissements, St. Dizier, Hte. Marne, France. (*Castings.*) (PARIS.)

Hadfields Steel Works, Ltd., Alexandria, Sydney, N.S.W. (*Castings and forgings.*) (SYDNEY.)

Hadfields (W.A.) 1934 Ltd., Perth, Western Australia. (*Castings.*) (FREMANTLE.)

HADIR, Société des Haut-Fourneaux et Aciéries de Differdange-St.Ingbert-Rumelange, Differdange Works, Luxembourg. (*Sections and bars.*) (SAARBRÜCKEN.)

Hainaut-Sambre, Société Métallurgiques, S.A., Couillet, Belgium.

Division de Couillet. (*Ingots, blooms, bars, forgings and castings.*) (ANTWERP.)

Division de Montignies et Chatelineau. (*Rolling mill.*) (ANTWERP.)

Haine St. Pierre et Lesquin, Aciéries de, Société Anonyme, Haine St. Pierre, Belgium. (*Castings.*) (ANTWERP.)

Lesquin-lez-Lille (Nord), France. (*Castings.*) (VALENCIENNES.)

Hakodate Dock Co., Ltd., Hakodate Shipyard, Hakodate, Japan. (*Small forgings and castings.*) (YOKOHAMA.)

Hallstahammar Aktiebolag, Hallstahammar, Sweden. (*Bars.*) (STOCKHOLM.)

Haneda Pipe Works Co., Ltd., Tokyo, Japan. (*Seamless tubes.*) (YOKOHAMA.)

Hatakeyama Iron Works Co., Ltd., Komatsugawa Works, Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Hawker Siddeley Canada Ltd., Trenton Works, Trenton, N.S. (*Forgings.*) (HALIFAX, N.S.)

Helsingors Skibsvaerft-og Maskinbyggeri A/S, Aktieselskabet, Elsinore, Denmark. (*Ingots, forgings and castings.*) (COPENHAGEN.)

d'Hennebont, Forges, Hennebont, Morbihan, France. (*Ingots, plates and castings.*) (NANTES.)

Henricot, Usines Emile, Court St. Etienne, Belgium. (*Castings.*) (ANTWERP.)

Hierros y Aceros Industriales S.A., San Adrian de Besos, Barcelona, Spain. (*Small castings.*) (BARCELONA.)

Hindustan Steel Ltd.,
Rourkela, Orissa, India. (*Ingots, slabs and plates.*) (CALCUTTA.)
Durgapur Steel Plant, West Bengal, India. (*Blooms, billets, bars and sections.*) (CALCUTTA.)
Bhilai Steel Project, Bhilai, Madhya Pradesh, India. (*Ingots, blooms, billets and sections.*) (CALCUTTA.)

d'Hirson S.A., Aciéries, Hirson, Aisne, France. (*Castings.*) (VALENCIENNES.)

Hitachi, Ltd.
Hitachi Works, Hitachi, Japan. (*Castings.*) (YOKOHAMA.)
Kasado Works, Kudamatsu, Japan. (*Castings and forgings.*) (SHIMONOSEKI.)
Katsuta Works, Katsutashi, Ibaragi-ken, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Hitachi Metal Industries, Ltd.
Yasugi Works, Yasugi, Japan. (*Ingots, bars and forgings.*) (KOBE.)
Tobata Works, Tobata, Japan. (*Castings.*) (SHIMONOSEKI.)

Hitachi Shipbuilding & Engineering Co., Ltd.
Chikko Shipyard, Osaka, Japan. (*Castings and forgings.*) (KOBE.)
Innoshima Shipyard, Innoshima, Japan. (*Forgings and small castings.*) (KOBE.)

Hoesch A.G., Hüttenwerke, Dortmund, Germany.
Phoenix Hörde Works, Dortmund-Hörde. (*Ingots, plates and castings.*) (DORTMUND.)
Union Works, Dortmund. (*Bars, sections and forgings.*) (DORTMUND.)
Westfalenhütte Works, Dortmund. (*Ingots, billets, plates, bars and sections.*) (Dortmund.)

Hokuriku Kogyo Co., Ltd., Sanjo Plant, Sanjo, Niigata Prefecture, Japan. (*Small forgings.*) (YOKOHAMA.)

Howa Machinery, Ltd., Inazawa Plant, Aichi Prefecture, Japan. (*Castings.*) (KOBE.)

Hults Bruk A.B., Aby, Sweden. (*Castings.*) (STOCKHOLM.)

Huta 1 Maja, Gliwice, Poland. (*Forgings.*) (KATOWICE.)

Huta Baildon, Katowice, Poland. (*Ingots, forgings and bars.*) (KATOWICE.)

Huta Batory, Chorzow-Batory, Poland. (*Forgings, plates and tubes.*) (KATOWICE.)

Huta Bierut, Czestochowa, Poland. (*Seamless tubes.*) (KATOWICE.)

Huta Bobrek, Bytom, Poland. (*Ingots, slabs and blooms.*) (KATOWICE.)

Huta im. M. Buczka, Sosnowiec, Poland. (*Seamless tubes.*) (KATOWICE.)

Huta Dzierzynski, Dabrowa Gornicza, Poland. (*Billets, sections and bars.*) (KATOWICE.)

Huta Florian, Swietochlowice, Poland. (*Angles and bars.*) (KATOWICE.)

Huta Jednosc, Siemianowice Slaskie, Poland. (*Ingots and seamless tubes.*) (KATOWICE.)

Huta Kosciuszko, Chorzow, Poland. (*Billets, blooms, sections and rivet bars.*) (KATOWICE.)

Huta Labedy, Labedy, Poland. (*Flats and sections.*) (KATOWICE.)

Huta im. Lenina, Krakow, Poland. (*Ingots, slabs, plates up to 12 mm.*) (KATOWICE.)

Huta Malapanew, Ozimek k/Opola, Poland. (*Castings.*) (KATOWICE.)

Huta Nowotko, Ostrowiec Swietokrzyski, Poland. (*Sections.*) (KATOWICE.)

Huta Pokoj, Ruda Slaska, Poland. (*Plates and sections.*) (KATOWICE.)

Huta Stalowa Wola, Stalowa Wola, Poland. (*Castings, forgings, plates and sections.*) (KATOWICE.)

Huta Z.M.G.S., Elblag, Poland. (*Castings.*) (GDANSK.)

Huta Zawiercie, Zawiercie, Poland. (*Flats and bars.*) (KATOWICE.)

Hüttenwerk Oberhausen A.G., Oberhausen, Germany. (*Ingots, plates, sections and bars.*) (DUSSELDORF.)

Hüttenwerke Siegerland A.G., Niederschelden, Germany. (*Ingots and slabs.*) (COLOGNE.)

Ilseder Hütte/Peine, Stahl- und Walzwerke, Peine, Germany. (*Ingots, billets, sections and bars.*) (HANNOVER.)

d'Imphy, Société Métallurgique.
Acieries d'Imphy (Nièvre), France. (*Ingots, forgings, bars and sections.*) (PARIS.)
Usine de Pamiers (Ariège), France. (*Castings and forgings.*) (MARSEILLES.)

Indian Iron & Steel Co., Ltd.
Burnpur Works, Burnpur, West Bengal, India. (*Sections and angles.*) (CALCUTTA.)
Kulti Iron Works, Kulti, India. (*Castings.*) (CALCUTTA.)

Indian Tube Company, (1953) Ltd., Jamshedpur, India. (*Seamless tubes.*) (CALCUTTA.)

Industrial Steels, Ltd., Lidcombe, Sydney, N.S.W., Australia. (*Castings.*) (SYDNEY.)

Industrias Mecanicas, Sociedad Anonima, Barcelona, Spain. (*Castings.*) (BARCELONA.)

Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Ingots, blooms, billets and slabs.*) (CHICAGO.)

Interprovincial Steel and Pipe Corporation Ltd., Regina, Saskatchewan, Canada. (*Plates.*) (TORONTO.)

Ishikawajima-Harima Heavy Industries Co., Ltd., Aioi Works, Aioi, Japan. (*Castings and forgings.*) (KOBE.)

Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Head Office: Via Corsica 4, Genoa, Italy.
S.I.A.C., Genoa. (*Ingots, forgings, plates and castings.*) (GENOA.)
Stabilimento di Bagnoli. (*Ingots, sections and bars.*) (NAPLES.)
Stabilimento di Lovere. (*Sections, bars, castings and forgings.*) (MILAN.)
Stabilimento di Marghera. (*Rolling mills for small sections and bars.*) (VENICE.)

Stabilimento di Portovecchio di Piombino. (*Ingots, blooms, sections and bars.*) (LEGHORN.)

Stabilimento di Taranto. (*Ingots, slabs and plates.*) (NAPLES.)

Stabilimento Oscar Sinigaglia, Genoa-Cornigliano. (*Ingots, slabs and plates.*) (GENOA.)

Izuo Chukosho Co., Ltd., Osaka, Japan. (*Castings.*) (KOBE.)

Jadot, Société Anonyme Etablissements, Beloeil, Belgium. (*Small castings.*) (ANTWERP.)

Japan Special Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings, blooms, billets and bars.*) (YOKOHAMA.)

Japan Steel Works Ltd.

Hiroshima Works, Hiroshima, Japan. (*Forgings and castings.*) (SHIMONOSEKI.)

Muroran Works, Muroran, Japan. (*Ingots, forgings, castings and plates.*) (YOKOHAMA.)

Jemappes, Société Anonyme Forges et Laminoirs de, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*) (ANTWERP.)

Jeumont, Forges et Ateliers de Constructions Electriques de, Jeumont (Nord), France. (*Castings.*) (VALENCIENNES.)

Jonan Iron Works Co., Ltd., Haneda Works, Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A. (CLEVELAND, O.)

Jorgensen, Earle, M. Co., Isaacson Division, P.O. Box 3970, Seattle, Washington.

K.G.M.-Altalanos Gepipari Igazgatosag, Budapest, Hungary.

Works: Öntödei Vallalat 1. sz., Gyára, Budapest. (*Castings.*) (VIENNA.)

K.G.M. Jármuipari Igazatóság, Budapest, Hungary.

Works: Magyar Vagon-és Gépgyár, Györ. (*Castings.*) (VIENNA.)

K.G.M. Vaskohászati Igazgatóság, Budapest, Hungary.

Works: Lenin Kohászati Müvek, Miskole-Diósgyör. (*Ingots, slabs, sections, bars, castings and forgings.*) (VIENNA.)

Works: Dunai Vasmü, Dunaujváros. (*Ingots, slabs and plates.*) (VIENNA.)

Works: Dunai Vasmü, Lörinci Hengermüve, Budapest. (*Rolling mill for plates.*) (VIENNA.)

Works: Ozdi Kohászati üzemek, Ozd. (*Ingots, slabs, plates, sections and bars.*) (VIENNA.)

Kaiser Steel Corporation, Fontana, Cal., U.S.A. (*Ingots and plates.*) (LOS ANGELES.)

Kakegawa Endo Iron Works Co., Ltd., Kakegawa, Japan. (*Forgings.*) (YOKOHAMA.)

Kansai Steel Corp., Sakai, Japan. (*Ingots, bars and flat bars.*) (KOBE.)

Kansai Tekko Co., Ltd., Amagasaki, Japan. (*Small forgings.*) (KOBE.)

Kanthal, A/B, Hallstahammar, Sweden. (*Ingots, billets, bars and castings.*) (STOCKHOLM.)

Kanto Special Steel Works, Ltd., Fujisawa, Kanagawa Pref., Japan. (*Forgings.*) (YOKOHAMA.)

Kawaguchi Kinzoku Kogyo Kabushiki Kaisha, Kawaguchi, Japan. (*Castings.*) (YOKOHAMA.)

Kawasaki Dockyard Co., Ltd., Kobe, Japan. (*Castings.*) (KOBE.)

Kawasaki Rolling Stock Mfg. Co., Ltd., Kobe, Japan. (*Castings.*) (KOBE.)

Kawasaki Steel Corporation.

Chiba Works, Chiba. (*Slabs and plates.*) (YOKOHAMA.)

Chita Works, Handa City. (*Ingots and castings.*) (KOBE.)

Fukiai Works, Kobe. (*Blooms, sections and plates.*) (KOBE.)

Hyogo Works, Kobe. (*Castings and forgings.*) (KOBE.)

Mizushima Works, Mizushima, Japan. (*Rolling mills for bars.*) (KOBE.)

Nishinomiya Works, Nishinomiya. (*Ingots and thin plates.*) (KOBE.)

Kilby Steel Co., Furnace Division, Anniston, Alabama, U.S.A. (*Ingots.*) (MOBILE.)

Kinka Kikai Co., Ltd., Gifu, Japan. (*Castings.*) (KOBE.)

Klafreströms Bruk, A/B., Klavreström, Sweden. (*Small castings.*) (GOTHENBURG.)

Klinger, Rich., Aktiengesellschaft, Gumpoldskirchen, near Vienna, Austria. (*Small castings.*) (VIENNA.)

Klöckner-Werke A.G.

Works: Georgsmarienwerke, Osnabrück, Germany. (*Ingots, bars, forgings and castings.*) (HANNOVER.)

Works: Hütte Bremen, Germany. (*Plates.*) (BREMEN.)

Works: Hütte-Haspe, Hagen-Haspe, Germany. (*Ingots, plates, bars and sections.*) (DORTMUND.)

Works: Mannstaedt-Werke, Troisdorf, Germany. (*Rolling mills for sections.*) (COLOGNE.)

Knorr-Bremse G.m.b.H., Volmarstein-Schmandbruch, Germany. (*Castings.*) (DORTMUND.)

Kobe Steel Ltd.

Works: Amagasaki, Japan. (*Ingots, plates, sections and bars.*) (KOBE.)

Works: Kobe, Japan. (*Ingots, blooms, billets, bars and castings.*) (KOBE.)

Works: Kure, Japan. (*Ingots, castings and small forgings.*) (HIROSHIMA.)

Works: Takasago, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Kockums Jernverk, Kallinge, Sweden. (*Castings.*) (MALMO.)

Kohlswa Jernverks Aktiebolag. (*Ingots, forgings and castings.*) (STOCKHOLM.)

Kokko Steel Works, Ltd., Osaka, Japan. (*Angles, bars and castings.*) (KOBE.)

Kokoku Chuko-sho K.K., Osaka, Japan. (*Castings.*) (KOBE.)

Komatsu Manufacturing Co., Ltd.

Komatsu, Japan. (*Castings.*) (KOBE.)

Osaka Plant, Hirakata, Osaka Prefecture, Japan. (*Castings.*) (KOBE.)

Koninklijke Demka Staalfabrieken N.V., Utrecht, Holland. (*Ingots, forgings, blooms, billets and castings; also rivet bars.*) (AMSTERDAM.)

Koninklijke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-furnaces & Steel Works, Ltd.), Ymuiden, Holland. (*Plates and sections.*) (AMSTERDAM.)

Kotobuki Kogyo Co., Ltd., Hiro Works, Kure, Japan. (*Castings.*) (HIROSHIMA.)

Krauss-Maffei A.G., München-Allach, Germany. (*Castings.*) (AUGSBURG.)

Kubota Iron & Machinery Works Ltd., Hirakata Plant, Hirakata, Osaka, Japan. (*Castings.*) (KOBE.)

Kure Shipbuilding & Engineering Co., Ltd., Kure, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Kureha Seiko Co. Ltd., No. 1 5-Chome Takeshima-Cho, Nishiyodogawa-Ku, Osaka, Japan. (*Castings.*) (KOBE.)

Kureha Seitetsu Co., Ltd., Toyama, Japan. (*Ingots.*) (YOKOHAMA.)

Kurimoto Iron Works Ltd., Kagaya Works, Osaka, Japan. (*Castings.*) (KOBE.)

Laminoirs, Société Anonyme des, Hauts-Fourneaux, Forges et Fonderies de la Providence, Hautmont (Nord), France. (*Ingots, plates and sections.*) (VALENCIENNES.)

Larssons, A/B P.S., Gjuteri & Aduceringsverk, Eskilduna, Sweden. (*Castings.*) (STOCKHOLM.)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Leonard-Giot, Société Anonyme Usines & Aciéries, Marchienne-au-Pont, Belgium. (*Castings.*) (ANTWERP.)

Lesjöfors Aktiebolag, Lesjöfors, Sweden. (*Ingots and bars.*) (GOTHENBURG.)

Lindener Eisen-und Stahlwerke G.m.b.H., Hannover-Linden, Germany. (*Ingots and castings.*) (HANNOVER.)

Llodio, Ltda., Aceros de, Llodio, near Bilbao, Spain. (*Small castings, ingots, forgings and rolled bars.*) (BILBAO.)

Lokomo Oy, Tampere, Finland. (*Ingots, forgings and castings.*) (ÅBO.)

Lorraine-Escaut S.A.

Departement Tubes, Usine d'Anzin, Anzin (Nord), France. (*Ingots and weldless rolled or drawn tubes.*) (VALENCIENNES.)

Usine de Longwy, Section Mont-St.-Martin, Mont-St.-Martin (Meurthe et Moselle), France. (*Sections and plates.*) (SAAR.)

Usine de Longwy, Section Senelle, Longwy-Bas (Meurthe et Moselle), France. (*Ingots, blooms, bars and sections.*) (SAAR.)

Usine de Sedan, Sedan (Ardennes), France. (*Plates.*) (VALENCIENNES.)

Usine de Thionville, Thionville (Moselle), France. (*Forgings.*) (SAAR.)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Castings.*) (LOS ANGELES.)

Luigi Giudici, Societa per Asioni, Rescaldina, Milan, Italy. (*Small castings.*) (MILAN.)

Lukens Steel Company, Coatesville, Pa., U.S.A. (*Plates.*) (PHILADELPHIA.)

Luzuriaga, Victorio, S.A., Pasajes, Guipuzcoa, Spain. *Works:* Lasarte, Nr. San Sebastian, Guipuzcoa. (*Castings.*) (BILBAO.)

Lynn Macleod Metallurgy Ltd., Thetford Mines, P.Q., Canada. (*Castings.*) (MONTREAL.)

Maekawa Electric Steel Castings Co., Osaka, Japan. (*Castings.*) (KOBE.)

Maitre & Cie, Ets, Colombie-Fontaine, (Doubs), France, *Small castings.*) (PARIS.)

Maizuru Shipbuilding & Eng. Co. Ltd., Maizuru Shipyard, Maizuru, Japan. (*Small forgings and castings.*) (KOBE.)

Makine ve Kimya Endustri, Celik Fabrikasi, Kirikkale, Turkey. (*Ingots, forgings, rolled sections and bars.*) (ISTANBUL.)

Mangolds Engineering, Port Elizabeth, South Africa. (*Small castings.*) (DURBAN.)

Manitoba Rolling Mills Division of Dominion Bridge Co., Ltd., Selkirk, Manitoba, Canada. (*Billets, bars and sections.*) (MONTREAL.)

Mannesmann A.G.

Hahnsche Werke, Duisburg-Grossenbaum, Germany (*Bars and electric resistance welded tubes.*) (DUSSELDORF.)

Huttenwerk Huckingen, Duisburg-Huckingen, Germany. (*Ingots, plates, sections and bars.*) (DUSSELDORF.)

Manufacturas de Acero S.A., Badalona, Barcelona, Spain. (*Small castings.*) (BARCELONA.)

Marine Nationale Indret, Etablissement de la, Loire-Atlantique, France. (*Castings.*) (NANTES.)

Maritime Steel and Foundries, Ltd., New Glasgow, Nova Scotia. (*Small castings.*) (HALIFAX, N.S.)

Marquise, Usines Métallurgiques de, Rinxent, Pas-de-Calais, France. (*Castings.*) (VALENCIENNES.)

Marrel Frères, Société Anonyme des Etablissements, Usine des Etaings, near Rive-de-Gier (Loire), France. (*Ingots, forgings, plates and bars.*) (MARSEILLES.)

Mason & Cox, Ltd., Adelaide, S. Australia. (*Castings.*) (ADELAIDE.)

Material y Construcciones S.A., Barcelona, Spain. (*Castings.*) (BARCELONA.)

Matsuya Kogyo Co., Ltd., Fukuoka, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Maubeuge, Société Anonyme de la Fabrique de Fer de, Louvroil (Nord), France. (*Ingots and plates.*) (VALENCIENNES.)

Maximilianshütte, Eisenwerk-Gesellschaft m.b.H., Sulzbach-Rosenberg, Bavaria, Germany.

Haidhof Works: (*Ingots, billets, bars, small sections and thin plates.*) (AUGSBURG.)

Rosenberg Works: (*Ingots and billets.*) (AUGSBURG.)

MECFOND—Officine Meccaniche e Fonderie Napoletane, Naples, Italy. (*Castings.*) (NAPLES.)

Meridionali, Acciaierie e Tubificio, S.p.A., Bari, Italy. (*Castings and weldless rolled or drawn tubes.*) (NAPLES.)

Meridionales, Fonderies, Marseilles, France. (*Castings.*) (MARSEILLES.)

Metal & Steel Factory, Ishapore, West Bengal, India. (*Ingots, blooms, billets, forgings and castings.*) (CALCUTTA.)

Metallurgica Marcora S.n.C., Busto Arsizio (Varese), Italy. (*Weldless rolled and drawn tubes.*) (MILAN.)

Metalurgica Duarte Ferreira S.A.R.L., Tramagal, Portugal. (*Castings.*) (LISBON.)

Meuse, Les Acieries de la, S.A., Cheratte-lez-Liege, Belgium. (*Castings.*) (ANTWERP.)

Meuse, Les Usines à Tubes de la, Flémalle-Haute, Belgium. (*Seamless tubes.*) (ANTWERP.)

Meuse, Société Métallurgique de la, Forges et Aciéries de Stenay, Stenay, Meuse. (*Small castings.*) (VALENCIENNES.)

MIAG (Mühlenbau und Industrie G.m.b.H.), Braunschweig, Germany. (*Castings.*) (HANNOVER.)

Midvale-Heppenstall Company, Nicetown, Philadelphia, Pa., U.S.A. (*Forgings.*) (PHILADELPHIA.)

Mitsubishi Steel Manufacturing Co., Ltd., Tokyo, Japan.
Hirota Works, Fukushima Pref. (*Castings.*) (YOKOHAMA.)
Tokyo Steel Works, Fukagawa Steel Manufacturing Dept. (*Billets, bars and small forgings.*) (YOKOHAMA.)
Tokyo Steel Works, Oshima Steel Manufacturing Dept. (*Rolling mills for billets and bars.*) (YOKOHAMA.)

Mitsubishi Nippon Heavy Industries Ltd., Yokohama Shipyard and Engine Works, Yokohama, Japan. (*Ingots, blooms, small forgings and castings.*) (YOKOHAMA.)

Mitsubishi Heavy Industries, Ltd.
Hiroshima Works, Hiroshima, Japan. (*Ingots, castings and small forgings.*) (SHIMONOSEKI.)
Kobe Shipyard & Engine Works, Kobe, Japan. (*Ingots and small forgings.*) (KOBE.)
Mihara Machinery Works, Mihara, Japan. (*Castings and forgings.*) (KOBE.)
Nagasaki Works, Nagasaki, Japan. (*Castings and small forgings.*) (NAGASAKI.)
Shimonoseki Shipyard & Engine Works, Shimonoseki, Japan. (*Small forgings.*) (SHIMONOSEKI.)
Takasago Machinery Works, Takasago, Japan. (*Forgings.*) (KOBE.)

Mitsubishi Steel Manufacturing Co., Ltd., Nagasaki Works, Nagasaki, Japan. (*Ingots, blooms, plates, forgings and castings.*) (NAGASAKI.)

Mitsui Miike Machinery Co., Ltd., Miike Works, Omutashi, Japan. (*Castings.*) (SHIMONOSEKI.)

Mitsui Shipbuilding & Engineering Co., Ltd., Tamano, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Mitsumoto Valve Manufacturing Co., Ltd., Domyoji, Osaka, Japan. (*Small forgings and small castings.*) (KOBE.)

Montluçon, Commentry, Société des Forges et Ateliers de, Usines St. Jacques, Montluçon (Allier), France. (*Castings, ingots, forgings, sheets and sections.*) (PARIS.)

Motala Verkstad, A/B, Motala Verkstad, Sweden. (*Ingots, forgings, castings, sections and bars.*) (GOTHENBURG.)

Mukand Iron & Steel Works, Ltd., Kurla, Bombay, 70, India. (*Castings.*) (BOMBAY.)

Nakayama Steel Works, Osaka, Japan. (*Ingots and plates.*) (KOBE.)

National Forge Co., Irvine, Warren County, Pennsylvania, U.S.A. (*Ingots and forgings.*) (CLEVELAND, O.)

National Iron & Steel Co., Ltd., Stephen House, Calcutta, 1, India. (*Castings.*) (CALCUTTA.)

National Castings Div., Midland Ross Corp., Sharon, Pa., U.S.A. (*Castings.*) (CLEVELAND.)

Nazionale "Cogne", S.p.A. *Head Office:* Turin. *Works:* Aosta. (*Ingots, forgings, plates, sections and bars.*) (GENOA.)

Neunkircher Eisenwerk A.G., Neunkirchen/Saar, Germany.
Neunkirchen Works. (*Ingots, bars and sections.*)
Homburg Works. (*Ingots and seamless tubes.*)

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Castings and forgings.*) (NEWPORT NEWS.)

Nicolacopoulos, G., & Co., Athens, Greece, Steelworks at Eleusis. (*Castings.*) (PIRÆUS.)

Nihon Cast Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Niigata Engineering Co., Ltd., Niigata, Japan. (*Castings, ingots and forgings.*) (YOKOHAMA.)

Nippon Chuzo Kabushiki Kaisha, Kawasaki, Japan. (*Ingots and castings.*) (YOKOHAMA.)

Nippon Kokan Kabushiki Kaisha.
Asano Dockyard, Yokohama, Japan. (*Small forgings.*) (YOKOHAMA.)
Kawasaki Iron Works, Kawasaki, Japan. (*Tubes, bars and sections.*) (YOKOHAMA.)
Mizue Ironworks, Kawasaki, Japan. (*Plates up to ½-inch in thickness.*) (YOKOHAMA.)
Tsurumi Iron Works, Tsurumi, Yokohama, Japan. (*Ingots and plates.*) (YOKOHAMA.)

Nippon Sharyo Seizo Kaisha, Ltd., Nagoya, Japan. (*Castings.*) (KOBE.)

Nippon Stainless Steel Co., Ltd., Naoetsu Works, Niigata, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Nippon Steel Foundry Co., Ltd., Osaka, Japan. (*Castings.*) (KOBE.)

Nippon Tanko Co., Ltd., Amagasaki, Japan. (*Small forgings.*) (KOBE.)

Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan. (*Ingots, forgings, bars and sheets.*) (YOKOHAMA.)

Nisshin Seiko Co., Ltd., Shikama Plant, Himeji, Japan. (*Rolled bars.*) (KOBE.)

Nisshin Steel Works, Ltd., Kure Works, Kure, Japan. (*Ingots, blooms, billets and strip.*) (SHIMONOSEKI.)

Nisso Steel Manufacturing Co., Ltd.
Naoetsu Factory, Naoetsu, Niigata, Japan. (*Ingots and castings.*) (YOKOHAMA.)
Oshima Plant, Tokyo, Japan. (*Castings, plates, and ingots for forging and plate.*) (YOKOHAMA.)
Toyama Factory, Toyama City, Japan. (*Ingots and forgings.*) (YOKOHAMA.)

Nittoku Metal Industry Co., Ltd., Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Nordische Stahlwerke, Bach & Co., Neumünster, Germany. (*Castings.*) (KIEL.)

Nordiska Armaturfabrikerna, A/B, Linköping, Sweden. (*Castings.*) (STOCKHOLM.)

Norrbottens Järnverk Aktiebolag, Lulea, Sweden. (*Ingots, slabs, blooms and billets, bars and sections.*) (STOCKHOLM.)

Norsk Jernverk, A/S., Mo-i-Rana, Norway. (*Electric steel ingots, billets, sections and bars.*) (OSLO.)

Nová hut' Klementa Gottwalda, národni podnik (New Metallurgical Works of Klement Gottwald, National Corporation), Ostrava-Kunčice, Czechoslovakia. (*Ingots and forgings.*) (VIENNA.)

Nueva Montana Quijano S.A., Nueva Montana, Santander, Spain. (*Castings.*) (BILBAO.)

Oesterreichisch-Alpine Montangesellschaft, Vienna.
Works: Donawitz, Styria. (*Sections and strip.*) (VIENNA.)
Works: Kindberg, Styria. (*Rolling mills for small sections, bars and strip.*) (VIENNA.)
Works: Traisen, Low Austria. (*Castings.*) (VIENNA.)
Works: Wördern, Low Austria. (*Ingots.*) (VIENNA.)
Works: Zeltweg, Styria. (*Forged bars.*) (VIENNA.)

Ohio Steel Foundry Co., Lima, Ohio, U.S.A. (*Ingots, forgings and castings.*)

Ohtani Heavy Industrial Co., Ltd., Amagasaki Plant, Amagasaki, Japan. (*Plates up to 12·5 mm. in thickness.*) (KOBE.)

Okamoto Iron Works Co., Kobe, Japan. (*Forgings.*) (KOBE.)

Okano Valve Manufacturing Co., Ltd., Moji. *Works:* Yukuhashi, Japan. (*Small castings.*) (SHIMONOSEKI.)

Olarra S.A.
Works: Erandio, Bilbao Spain. (*Ingots and small bars.*) (BILBAO.)
Works: Larrondo, Lujua, Vizcaya, Spain. (*Ingots and rolled bars.*) (BILBAO.)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Castings.*) (SEATTLE.)

Onomichi Anchor Manufacturing Co., Ltd., Onomichi, Japan. (*Castings.*) (KOBE.)

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka, Japan. (*Small castings.*) (KOBE.)

Osaka Shipbuilding Co., Ltd., Taira Steel Works, Taira City, Fukushima Prefecture, Japan. (*Castings.*) (YOKOHAMA.)

Osaka Steel Casting Co., Ltd., Osaka, Japan. (*Small castings.*) (KOBE.)

Osaka Steel Tube Co., Ltd., Sasebo Works, Sasebo, Japan. (*Seamless tubes.*) (NAGASAKI.)

Otani Steelworks, Ltd., Osaka, Japan. (*Ingots and plates.*) (KOBE.)

Oxelosunds Jarnverk, Oxelosund, Sweden. (*Ingots, rolled slabs and plates.*) (STOCKHOLM.)

Oy Fiskars, AB, Äminnefors Bruk, Äminnefors, Finland. (*Ingots, billets, bars and sections.*) (ÅBO.)

Oy Wärtsilä AB. Dalsbruk, Finland. (*Ingots, billets, bars, castings and forgings.*) (ÅBO.)

Ozuki Seikosho, Ltd., Shimonoseki, Japan. (*Castings.*) (SHIMONOSEKI.)

Pacific States Steel Corporation, Union City, Cal., U.S.A. (*Ingots, sections and bars.*) (SAN FRANCISCO.)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Pacifico, Compañia de Acero del, S.A., Talcahuano, Chile. (*Ingots, plates, bars and sections.*) (SANTIAGO.)

Paderwerk Gebr. Benteler, Schlossneuhaus, Germany. (*Seamless tubes.*) (DORTMUND.)

Paris et d'Outreau, Aciéries de, Société Anonyme, Usine d'Outreau, Pas de Calais, France. (*Castings.*) (VALENCIENNES.)

Paris-Seine, Fonderies et Aciéries de, Usine de la Folie, Avenue de Bobigny, Noisy le Sec (Seine), France. (*Castings.*) (PARIS.)

Penn Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Pennsylvania Steel Foundry and Machine Company, Hamburg, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Pennsylvania Forge, Division of Chemetron Corporation, Tacony, Philadelphia, 35, Pa., U.S.A. (*Forgings.*) (PHILADELPHIA.)

Phoenix Steel Corporation.
Works: Claymont, Delaware, U.S.A. (*Plates.*) (PHILADELPHIA.)
Works: Structural Division, Phoenixville, Pa., U.S.A. (*Sections, bars and rotary forged seamless tubes.*) (PHILADELPHIA.)

Pittsburgh Steel Company, Pittsburgh 30, Pa., U.S.A.
Works: Monessen, Pa. (*Ingots, billets and slabs.*) (CLEVELAND, O.)
Works: Allenport, Pa. (*Rolling mills.*) (CLEVELAND, O.)

Pohlig-Heckel-Bleichert, Vereinigte Maschinenfabriken A.G., Abt. Stahlformgiesserei, Werk Heckel, Rohrbach/Saar, Germany. (*Castings.*) (SAARBRÜCKEN-SAAR.)

Pompey, Société des Aciéries de.
Usine de Pompey, Meurthe & Moselle, France. (*Ingots, blooms, billets, plates, angles and round bars.*) (SAARBRÜCKEN-SAAR.)
Usine du Manoir à Pitres, Eure, France. (*Castings.*) (ROUEN.)

Porter, H. K. (France) Acieries Division Marpent, Marpent (Nord), France. (*Castings.*) (VALENCIENNES.)

Pracchi, Fonderie Elettriche O., S.p.A., Milan, Italy. (*Small castings.*) (MILAN.)

Provence, Fonderies et Aciéries de, Marseilles, France. (*Castings.*) (MARSEILLES.)

Providence, Société Anonyme des Forges de la, Marchienne-au-Pont, Belgium. (*Sections, bars, ingots and blooms*). (ANTWERP.)

Quaker Alloy Casting Co., Myerstown, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Raahe Oy, Raahe, Finland. (*Small castings.*) (ÅBO.)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*) (STOCKHOLM.)

Raufoss Ammunisjonsfabrikker, Raufoss, Norway. (*Castings.*) (OSLO.)

Republic Steel Corporation, Cleveland, O., U.S.A.
- Alabama City, Ala., U.S.A. (MOBILE, ALA.)
- Buffalo Plant, Buffalo, N.Y., U.S.A. (CLEVELAND,O.)
- Central Alloy District, Massillon Plant, Massillon, O., U.S.A. (CLEVELAND, O.)
- Chicago Plant, Chicago, Ill., U.S.A.
  - *Works :* 118th Street, Chicago. (*Rolling mills.*)
  - East Chicago, Ind. (*Angles and bars.*) (CHICAGO.)
- Cleveland District, Cleveland, O., U.S.A. (CLEVELAND, O.)
  - Corrigan McKinney Plant. (*Ingots, blooms and billets.*)
  - Upson Nut Plant. (*Round and square bars.*)
- Youngstown District, Youngstown, O., U.S.A. (CLEVELAND, O.)

Rheinstahl Hüttenwerke, A.G.,
- Werk Friedrich Wilhelms-Hütte, Mulheim und Meiderich, Germany. (*Castings.*) (DUSSELDORF.)
- Werk Ruhrstahl Henrichshütte, Hattingen, Germany. (*Ingots, plates, forgings and castings.*) (DORTMUND.)
- Werk Schalker Verein, Gelsenkirchen, Germany. (*Castings.*) (DUSSELDORF.)

Riken Tanzo Co., Ltd., Maebashi Plant, Maebashi, Japan. (*Small forgings.*) (YOKOHAMA.)

Rikimi Cast Steel Co., Ltd., Osaka, Japan. (*Small castings.*) (KOBE.)

Röchling'sche Eisen-und Stahlwerke G.m.b.H., Völklingen, Saar. (*Castings, ingots, billets, bars and forgings.*) (SAARBRÜCKEN-SAAR.)

Rosenlew, W., & Co., A/B Björneborgs Mekaniska Verkstad, Björneborg, Finland. (*Small castings.*) (ÅBO.)

Rotterdamsche Droogdok Maatschappij, Rotterdam, Holland. (*Ingots, forgings and small castings.*) (ROTTERDAM.)

S.A.F.A.S.—Societa Azionaria Fonderia Acciai Speciali, Tavernelle di Altavilla Vicentina (Vicenza), Italy. (*Castings.*) (VENICE.)

S.A.F.A.U. Ferriere Acciaierie di Udine, Udine, Italy. (*Ingots, forgings, blooms, bars and sections.*) (TRIESTE.)

S.A.F.E. Société Aciers Fins de l'Est, Hagondange, Moselle, France. (*Ingots, blooms, billets, bars, plates and sheet.*) (SAAR.)

Salzgitter Hüttenwerk A.G., Salzgitter-Drütte, Germany. (*Ingots, plates, bars and sections.*) (HANNOVER.)

Sambre, Aciéries & Minières de la.
- *Works :* Monceau-sur-Sambre, Belgium. (*Sections, bars, billets and blooms.*) (ANTWERP.)
- *Works :* Moncheret, near Acoz. (*Rolling mills for bars.*) (ANTWERP.)

Sambre et Meuse, Société Anonyme des Usines et Aciéries de.
- Usines de Feignies, Feignies (Nord), France. (*Castings.*) (VALENCIENNES.)
- Usines de Saint Brieuc, Cotes-du-Nord, France. (*Small castings.*) (NANTES.)

Sande Giesserei, Sande-Oldenburg, Germany. (*Castings.*) (EMDEN.)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Ingots, forgings and tubes.*) (STOCKHOLM.)

"Santa Barbara," Sociedad Industrial Asturiana, Gijon, Spain. (*Forgings.*) (GIJON.)

Sanyo Special Steel Co., Ltd., Himeji, Japan. (*Ingots, forgings and rolled bars.*) (KOBE.)

Sasebo Heavy Industries Co., Ltd., Sasebo, Japan. (*Castings and forgings.*) (NAGASAKI.)

Saut-du-Tarn, Société Anonyme des Forges et Aciéries du, Saint-Juery (Tarn), France. (*Castings.*) (MARSEILLES.)

Scaw Metals, Ltd., Union Junction, Transvaal, S. Africa. (*Rivet bars, small rolled sections and castings.*) (VEREENIGING.)

Schmidt & Clemens, Edelstahlwerk, Berghausen b/Engelskirchen, Bez. Köln, Germany. (*Ingots, forgings, castings and bars.*) (COLOGNE.)

Schoeller-Bleckmann Stahlwerke A.G., Vienna.
- *Works :* Muerzzuschlag-Hoenigsberg, Styria. (*Bars.*) (VIENNA.)
- *Works :* Ternitz, Low Austria. (*Castings, forgings and bars.*) (VIENNA.)

Schutte, Meyer & Co., G.m.b.H., Letmathe, Westphalia, Germany. (*Small castings.*) (DORTMUND.)

Schutze,—Werke G.m.b.H. Ludwigshafen/Rhein, Germany. (*Electric steel castings.*) (MANNHEIM.)

Seo Koatsu Kogyo Co., Ltd., Osaka, Japan. (*Small forgings.*) (KOBE.)

Sharon Steel Corporation, Roemer Works, Farrell, Pa., U.S.A. (*Ingots, blooms, billets, narrow plates and sections.*) (CLEVELAND.)

Shimizu Forge Co., Ltd., Tokyo, Japan. (*Forgings.*) (YOKOHAMA.)

Shin Nippon Tanko K.K., Kawasaki, Japan. (*Small forgings.*) (YOKOHAMA.)

Siderurgia Nacional, S.a.r.l., Seixal, Portugal. (*Sections and bars.*) (LISBON.)

S.I.F.E.M.A. S.A., Bilbao, Spain. (*Steel castings.*) (BILBAO.)

S.I.S.M.A.—Società Industrie Siderurgiche Meccaniche & Affini, Villadossola (Novara), Italy. (*Rolled bars and rivets.*) (MILAN.)

SKF. Hofors Bruk, Hofors, Sweden. (*Billets, bars and forgings, and thick walled tubes.*) (STOCKHOLM.)

Škoda, Oborový Podnik, Plzeň, Hungary. (*Castings and forgings.*) (VIENNA.)

Smedjebackens Valsverks Aktiebolag, Smedjebacken, Sweden. (*Bars, sections and ingots for re-rolling.*)

Società Metallurgica Vittorio Cobianchi S.p.A.

Head Office: Milan, Italy.

Works: Omegna (NOVARA.) (*Castings*) (MILAN.)

Société Anonyme d'Exploitation des Aciéries de Bordeaux, Pessac, Gironde, France. (*Castings.*) (BORDEAUX.)

Société Anonyme des Forges et Aciéries de Dilling, Dillingen, Sarre. (*Ingots and plates.*) (SAARBRÜCKEN-SAAR.)

Société Belge Griffin S.A., Merxem, Antwerp, Belgium. (*Castings.*) (ANTWERP.)

Société Lorraine de Laminage Continu, Sollac, B.P.13, Serémange, Moselle, France. (*Ingots, slabs and plates.*) (SAAR.)

Société Métallurgique de Normandie, Mondeville, France. (*Ingots, blooms, billets and bars.*) (ROUEN.)

Société Mosellane de Siderurgie, Hagondange (Moselle), France. (*Blooms, billets, bars and sections.*) (SAAR.)

Sollinger Hütte G.m.b.H., Uslar/Solling, Germany. (*Castings.*) (HANNOVER.)

Sorel Industries, Ltd., Sorel, P.Q., Canada. (*Ingots and forgings.*) (MONTREAL.)

South African Iron & Steel Industrial Corporation, Ltd., "Iscor" Works, Pretoria, Transvaal, S. Africa. (*Ingots, billets, sections and thin plates up to $\frac{3}{8}$ inch thick.*) (VEREENIGING.)

"Iscor" Works, Vanderbijl Park, Transvaal, S. Africa. (*Ingots, billets, slabs and plates.*) (VEREENIGING.)

Stahl-u. Röhrenwerke Reisholz G.m.b.H., Germany.

Works at Reisholz. (*Ingots and seamless tubes.*)

Works at Oberbilk. (*Forgings.*) (DUSSELDORF.)

Stahlwerk Mannheim A.G., Mannheim-Rheinau, Germany. (*Ingots, forgings and castings.*) (MANNHEIM.)

Stahlwerk Mark, Wengern A.G., Wengern-Ruhr, Germany. (*Ingots and castings.*) (DORTMUND.)

Stahlwerk Südwestfalen, A.G.

Werk Geisweid, Geisweid Kreis Siegen, Germany. (*Ingots, bars, billets, thin plates, sheets and coils.*) (COLOGNE.)

Werk Harkort Eicken, Hagen, Germany. (*Ingots, bars and forgings.*) (DORTMUND.)

Stahlwerke Bochum A.G., Bochum, Germany. (*Castings, forgings, rolled materials and plates.*) (DUSSELDORF.)

Stahlwerke Röchling-Buderus A.G., Wetzlar, Germany. (*Ingots, blooms, billets, bars, forgings and plates.*) (COLOGNE.)

Stål och Maskinaktiebolaget, Upsala, Sweden. (*Ingots.*) (STOCKHOLM.)

Standard Steel Division of Baldwin-Lima-Hamilton Corp., Burnham, Mifflin County, Pa., U.S.A. (*Castings and forgings.*) (PHILADELPHIA.)

Stavanger Electro-Staalverk A.S., Jørpeland, near Stavanger, Norway. (*Castings.*) (BERGEN.)

Steel Company of Australia, Pty. Ltd., Coburg, Melbourne, Australia. (*Castings.*) (MELBOURNE.)

Steel Company of Canada, Hamilton, Ontario, Canada.

Works: Hamilton. (*Bars and angles, plates and billets.*) (TORONTO.)

Works: Montreal. (*Bars, angles, plates and billets.*) (MONTREAL.)

Steirische Gusstahlwerke, A.G., Vienna. *Works:* Judenburg, Styria, Austria. (*Forgings and bars.*) (VIENNA.)

Stenberg, Oy John, A.B., Helsingfors, Finland. (*Small castings.*) (HELSINGFORS.)

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

Works: Domnarfvet. (*Castings, ingots, sections and plates.*) (STOCKHOLM.)

Works: Söderfors. (*Forgings, bars and sections.*) (STOCKHOLM.)

Stramezzi, P., & C., Acciaieria e Ferriera di Crema, Crema, Italy. (*Ingots, bars, small sections and rivets.*) (MILAN.)

Streicher, M., Asperg/Württ, near Stuttgart, Germany. (*Castings.*) (AUGSBURG.)

Stridsberg & Biorck, A.B., Trollhattan, Sweden. (*Castings.*) (GOTHENBURG.)

Strömmens Verksted, A/S, near Oslo, Norway. (*Castings.*) (OSLO.)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Castings.*) (BARCELONA.)

Sud Ouest, Société des Forges et Aciéries du, Bordeaux (Gironde), France. (*Castings and forgings.*) (BORDEAUX.)

Sulzer Bros. Ltd., Winterthur, Switzerland. (*Castings.*) (WINTERTHUR.)

Sumitomo Electric Industries, Ltd., Itami Works, Itami, Hyogo Prefecture, Japan. (*Ingots and small bars.*) (KOBE.)

Sumitomo Machinery Co., Ltd., Niihama, Japan. (*Castings.*) (KOBE.)

Sumitomo Metal Industries, Ltd.

Kokura Steel Works, Kitakyushu-City, Japan. (*Ingots, billets, bars and sections.*) (SHIMONOSEKI.)

Osaka Steel Works, Osaka. (*Castings, forgings and bars.*) (KOBE.)

Steel Tube Works, Amagasaki, Japan. (*Ingots, forgings, small bars, sections and weldless tubes.*) (KOBE.)

Wakayama Steel Works, Wakayama, Japan. (*Ingots, plates, seamless tubes and electric resistance welded tubes.*) (KOBE.)

Sunnan Iron Works Co., Ltd., Yaizu, Japan. (*Forgings.*) (YOKOHAMA.)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Plates, forgings and castings.*) (STOCKHOLM.)

Svenska Jarnvagsverkstaderna, A/B, Linköping, Sweden. (*Castings.*) (STOCKHOLM.)

Svenska Kullagerfabriken, A/B,
Works: Katrineholm, Sweden. (*Castings.*) (STOCKHOLM.)
Works: Hellefors Jernverk, Hällefors, Sweden. (*Ingots and bars.*) (GOTHENBURG.)

Takada Steel Works, Ltd., Takada City, Nara Prefecture, Japan. (*Castings.*) (KOBE.)

Takasaki Metal Industry Co., Ltd., Takasaki Plant, Takasaki, Japan. (*Small castings.*) (YOKOHAMA.)

Tamaris, Société des Ateliers et Fonderies de, Tamaris (Gard), France. (*Castings.*) (MARSEILLES.)

Tassara S.A., Carlo, and Metalcam S.p.A., Breno, Brescia, Italy. (*Ingots, bars and small forgings.*) (MILAN.)

Tata Engineering & Locomotive Co., Ltd., Jamshedpur 4, India. (*Castings.*) (CALCUTTA.)

Tata Iron & Steel Co., Ltd., Jamshedpur, India. (*Blooms, billets, bars, plates and sections.*) (CALCUTTA.)

Teikoku Kokan Seizosho K.K., Osaka, Japan. (*Seamless tubes.*) (KOBE.)

Teil, Fonderies & Aciéries du, Usine du Frayol, Le Teil (Ardeche), France. (*Small castings.*) (MARSEILLES.)

Temple, Acieries du, Saint-Michel de Maurienne, (Savoie) France. (*Rolled and forged bars and billets.*) (MARSEILLES.)

Tennessee Coal & Iron Division, United States Steel Corporation, Birmingham, Ala., U.S.A. *Works:* Ensley, Ala. *Rolling mills, also forgings:* Bessemer and Fairfield, Ala. (MOBILE.)

"Terni" Società per l'Industria e l'Elettricità. *Works:* Terni, Italy. (*Ingots, forgings, castings and plates.*) (NAPLES.)

Thyssen-Rohrenwerke A.G., Mülheim (Ruhr), Germany. (*Plates*) (DUSSELDORF.)

Titovi Zavodi Litostroj, Ljubljana, Yugoslavia. (*Castings.*) (SPLIT.)

Tohoku Special Steel Works Ltd., Sendai, Japan. (*Ingots, small forgings, billets and bars.*) (YOKOHAMA.)

Tokushu Seiko (Special Steel Mfg.) Co., Ltd., Kawasaki Works, Kawasaki, Japan. (*Ingots, forgings and bars.*) (YOKOHAMA.)

Tokyo Kikai Kabushiki Kaisha, Oshima Cast Steel Works, Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Tokyo Precision Forging Works Co., Ltd. (Tokyo Seitan Works Co., Ltd.), Ichikawa City, Chiba Prefecture, Japan. (*Small forgings.*) (YOKOHAMA.)

Tokyo Shibaura Electric Co., Ltd., Turbine Works, Yokohama, Japan. (*Small castings*). (YOKOHAMA.)

Tokyo Steel Casting Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Tokyo Tankosho Co., Ltd., Kawasaki Factory, Kawasaki, Japan. (*Small forgings.*) (YOKOHAMA.)

Topy Industries Ltd.,
Tokyo Works, Tokyo, Japan. (*Sections.*) (YOKOHAMA.)
Toyohashi Works, Toyohashi, Japan. (*Ingots, sections and flat bars.*) (KOBE.)

Toshiba Steel Co., Ltd., Tokyo, Japan. (*Castings, small forgings, sections and ingots for forging and plates.*) (YOKOHAMA.)

Tosi, Franco, Società per Azioni, Legnano, Italy. (*Forgings and castings.*) (MILAN.)

Toyo Kikai-Kinzoku Co. Ltd., Tsuchiyama Plant, Akashi, Japan. (*Small castings.*) (KOBE.)

Třinecké železárny velké Rijnové socialistické revoluce, národni podnik (Třinec Iron Works Great-Socialistic October Revolution National Corporation), Třinec, Czechoslovakia. (*Ingots, sections, bars and castings.*) (VIENNA.)

Trubia, Fábrica Nacional de, Trubia Asturias, Spain. (*Castings and forgings.*) (GIJON.)

Turkiye Demir ve Celik Isletmeleri, Karabuk, Turkey (*Ingots, thin plates, rolled sections and bars.*) (ISTANBUL.)

Tvornica Dizalica I. Ljevaonica "Vulkan", Rijeka II, Yugoslavia. (*Castings.*) (RIJEKA.)

Tweer, Reinhard, G.m.b.H., Brackwede/Westf., Germany. *Works:* Kracks Nr. Bielefeld. (*Castings.*) (HANNOVER.)

Ube Industries, Ltd., Ube Machinery Works, Ube, Japan. (*Ingots, forgings and castings.*) (SHIMONOSEKI.)

Uddeholms Aktiebolag, Uddeholm, Sweden.
Works: Degerfors. (*Ingots, plates, sections and bars.*) (GOTHENBURG.)
Works: Hagfors. (*Castings.*) (GOTHENBURG.)
Works: Nykroppa. (*Ingots.*) (GOTHENBURG.)
Works: Storfors. (*Seamless tubes.*) (GOTHENBURG.)

Ugine, Aciéries Electriques d', Ugine (Savoie), France. (*Ingots, billets, bars, sections, castings and forgings.*) (MARSEILLES)

União Fabril, Companhia, Barreiro, Portugal. (*Castings.*) (LISBON.)

Union de Siderurgicas, Asturianas, S.A. (UNINSA).
Fabrica de Mieres, Asturias, Spain. (*Sections, bars and plates up to 15 mm. in thickness.*) (GIJON.)
Fabrica de Gijon, Gijon, Spain. (*Rivet bars and castings.*) (GIJON.)
Fabrica de La Felguera, La Felguera, Asturias, Spain. (*Ingots, billets, plates and sections.*) (GIJON.)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi, Belgium. (*Castings.*) (ANTWERP.)

Union Sidérurgique Lorraine, SIDELOR.

Usine d'Homécourt, Meurthe et Moselle, France. (*Ingots, blooms, billets and universal flats.*) (SAAR.)

Usine de Micheville, Villerupt, Meurthe et Moselle, France. (*Ingots, blooms, billets, bars and sections.*) (SAAR.)

Usine de Rombas, Moselle, France. (*Ingots, blooms, billets, bars and sections.*) (SAAR.)

Union Sidérurgique du Nord de la France.

Usine de Dunkerque, Dunkerque (Nord). (*Ingots and plates.*) (DUNKERQUE.)

USINOR GROUPE A.

Usines de Denain, Denain (Nord). (*Ingots, plates, sections and castings.*) (VALENCIENNES.)

USINOR GROUPE B.

Usines de Louvroil-Hautmont, Hautmont (Nord). (*Ingots, bars and sections.*) (VALENCIENNES.)

Usines de Valenciennes, Valenciennes (Nord). (*Ingots, forgings, blooms, bars and sections.*) (VALENCIENNES.)

Union Steel Corporation of South Africa, Ltd. (Usco).

Works: Vereeniging, Transvaal, South Africa. (*Ingots, billets, small sections, castings and rivet bars.*) (VEREENIGING.)

United States Steel Corporation, Pittsburgh, Pa., U.S.A.

Clairton Works, Clairton, Pa. (*Ingots, blooms, bars and sections.*) (CLEVELAND, O.)

Duquesne Works, Duquesne, Pa. (*Ingots, billets, blooms and bars.*) (CLEVELAND, O.)

Fairless Works, Morrisville, Pa. (*Thin plates, bars and sections.*) (PHILADELPHIA.)

Gary Works, Gary, Ind. (*Billets, blooms, plates, sections, bars and forgings.*) (CHICAGO.)

Geneva Works, Provo, Utah. (*Plates.*) (LOS ANGELES.)

Homestead District Works, Pa., including McKees Rock Works. (*Ingots, billets, blooms, slabs, plates, sections and forgings.*) (CLEVELAND, O.)

Irvin Works, Dravosburg, Pa. (*Rolling mills for thin plates.*) (CLEVELAND, O.)

McDonald Mills, Youngstown. (*Rolling mills for bars and sections.*) (CLEVELAND, O.)

Ohio Works, Youngstown. (*Ingots, billets and blooms.*) (CLEVELAND, O.)

South Works, South Chicago, Ill. (*Plates, sections and bars.*) (CHICAGO.)

Torrance Works, Torrance, Calif. (*Round bars and sections.*) (LOS ANGELES.)

Uraga Shipbuilding Yard, Uraga Heavy Industries, Ltd., Yokosuka, Japan. (*Castings and small forgings.*) (YOKOHAMA.)

Usinas Siderurgicas de Minas Gerais S.A., Belo Horizonte, Estado de Minas Gerais, Brazil.

Works: Ipatinga, Estado de Minas Gerais. (*Ingots, slabs and plates.*) (RIO DE JANEIRO.)

Vallourec, Société, Usine d'Aulnoye, Aulnoye (Nord), France. (*Weldless rolled and drawn tubes.*) (VALENCIENNES.)

Vanderbijl Engineering Corporation, Ltd., Vanderbijl Park, Transvaal, South Africa. (*Castings.*) (VEREENIGING.)

Varde Staalvaerk, Varde, Denmark. (*Ingots and castings.*) (ODENSE.)

Vereinigte Oesterreichische Eisen-und-Stahlwerke, A.G.

Works: Liezen, Styria. (*Ingots for forgings, castings.*) (VIENNA.)

Works: Linz a.d. Donau, Upper Austria. (*Plates, forgings and castings.*) (VIENNA.)

Vickers Ruwolt Pty., Ltd., Richmond, Melbourne, Australia. (*Steel castings and ingots.*) (MELBOURNE.)

Victoria Machinery Depot Co., Ltd., Victoria, B.C., Canada. (*Castings.*) (VANCOUVER.)

Villa, Giovanni, S.p.A., Officine Meccaniche-Fucinati-Stampati, Milan, Italy. (*Forgings.*) (MILAN.)

Viomichania Chalyvon Ltd., Athens, Greece. (*Castings.*) (PIRÆUS.)

Vitkovické Železárny Klementa Gottwalda, národni podnik (The Vitkovice Steel Works Klement Gottwald, National Corporation), Ostrava 10, Czechoslovakia. (*Castings, forgings, plates, sections, bars and seamless tubes.*) (VIENNA.)

Vizcaya, Altos Hornos de, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Ingots, plates, bars and sections.*) (VALENCIA.)

Vizcaya, Sociedad Altos Hornos de, Bilbao, Spain. (*Ingots, bars, sections, plates and forgings.*) (BILBAO.)

Von Roll A.-G., Gerlafingen, Switzerland. (*Ingots, round bars and forgings.*) (WINTERTHUR.)

Vuoksenniska Oy Aktiebolag, Imatra Steel Works, Imatra, Finland. (*Ingots, slabs, blooms and billets, bars, sections and castings.*) (HELSINGFORS.)

Waagner-Biro Aktiengesellschaft, Vienna, Austria.

Works: Werk C, Vienna. (*Castings.*) (VIENNA.)

Wakamatsu Sharyo Co., Ltd., Kitakyushu-City, Japan. (*Small castings.*) (SHIMONOSEKI.)

Walkers Ltd., Maryborough, Queensland, Australia. (*Forgings and castings.*) (BRISBANE.)

Washington Iron Works, Seattle, Wash., U.S.A. (*Castings.*) (SEATTLE.)

Washino Machine Co., Ltd., Imamura Plant, Aichi Prefecture, Japan. (*Castings.*) (KOBE.)

Watanabe Steel Works Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Welmet Industries Ltd., Welland, Ontario, Canada. (*Small castings.*) (TORONTO.)

Western Canada Steel Ltd., (Vancouver Rolling Mills Ltd.,) Vancouver, B.C., Canada. (*Sections and bars.*) (VANCOUVER.)

Wikmanshytte Bruks A/B, Wikmanshyttan, Sweden. (*Forgings, bars and sections.*) (STOCKHOLM.)

Wood, Alan, Steel Company, Conshohocken, Pa., U.S.A. (*Blooms, billets and plates.*) (PHILADELPHIA.)

Wurth, Société Anonyme des Anciens Etablissements Paul, Luxembourg. (*Castings.*) (SAAR.)

Yamato Steel Works, Ltd., Osaka, Japan. (*Ingots, sections and plates.*) (KOBE.)

Yawata Iron & Steel Co., Ltd., Yawata Works, Kitakyushu City, Japan.

Tobata Area Works, (*Plates and ingots.*) (SHIMONOSEKI.)

Sakai Works, Sakai, Osaka. (*Ingots and sections.*) (KOBE.)

Yawata Area Works, (*Plates, sections, ingots and forgings.*) (SHIMONOSEKI.)

Yawata Steel Tube Co., Ltd., Tokyo, Japan. (*Rolling mills for weldless, rolled or drawn tubes.*) (YOKOHAMA.)

Yokohama Engineering Co., Ltd., Tokyo Works, Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Yonago Steel Works, Ltd., Yonago, Japan. (*Castings.*) (KOBE.)

Youngstown Sheet and Tube Company.

Brier Hill Works, Youngstown, Ohio, U.S.A.

Campbell Works, Campbell, Mahoning Co., Ohio, U.S.A. (*Ingots, and plates up to* 12·5 *mm. in thickness.*) (PITTSBURGH.)

Zaklady Budowy Przewodow i Armatury, Kielce, Poland. (*Castings.*) (KATOWICE.)

Zaklady Metalurgiczne, Poznan, "Pomet" Poznan, ul Krancowa 15, Poland. (*Castings.*) (GDANSK.)

Zaklady Urzadzen Technicznych "Zgoda", Swietochlowice, Poland. (*Forgings.*) (KATOWICE.)

Zelezarna Jesenice, Jesenice, Yugoslavia. (*Plates, bars, sections and small castings.*) (SPLIT.)

Zelezarna Ravne, Ravne na Koroskem, Yugoslavia. (*Castings, forgings, billets and bars.*) (RIJEKA.)

Zelezárny a drátovny Bohumin, národni podnik (Iron Works and Wire Works Bohumin, National Corporation), Bohumin, Czechoslovakia. (*Small sections and bars.*) (VIENNA.)

Zeljezara "Boris Kidric", Niksic, Yugoslavia. (*Plates and castings.*) (SPLIT.)

Zeljezara Sisak, Sisak-Predgradje, Yugoslavia. (*Seamless tubes.*) (RIJEKA.)

Zeljezara Zenica, Zenica, Yugoslavia. (*Billets, bars, sections and forgings.*) (SPLIT.)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND (ARRANGED ACCORDING TO SURVEYING DISTRICTS)

Åbo

Ahlström, A., Oy, Karhulan Tehtaat, Karhula Bruk, Karhula, Finland. (*Castings.*)

Lokomo Oy, Tampere, Finland. (*Ingots, forgings and castings.*)

Oy Fiskars AB, Äminnefors Bruk, Äminnefors, Finland. (*Ingots, billets, bars and sections.*)

Oy Wärtsilä AB. Dalsbruk, Finland. (*Ingots, billets, bars, forgings and castings.*)

Raahe Oy, Raahe, Finland. (*Small castings.*)

Rosenlew, W., & Co., A/B Björneborgs Mekaniska Verkstad, Björneborg, Finland. (*Small castings.*)

Adelaide

Bradford Kendall Ltd., Adelaide, South Australia. (*Castings.*)

Mason & Cox Ltd., Adelaide, S. Australia. (*Castings.*)

Amsterdam

Dikkers, G., & Co., N.V., Hengelo, Holland. (*Small castings.*)

Koninklijke Demka Staalfabrieken, N.V., Utrecht, Holland. (*Ingots, forgings, blooms, billets and castings; also rivet bars.*)

Koninklijke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-Furnaces & Steel Works, Ltd.), Ymuiden, Holland. (*Plates and sections.*)

Antwerp

Allard, Usines & Aciéries, Société Anonyme, Mont-sur-Marchienne, near Charleroi. (*Castings.*)

Allard, Usines & Aciéries, Société Anonyme, Turnhout. (*Small castings.*)

Baume, Société Anonyme des Forges et Laminoirs de, Haine St. Pierre. (*Ingots, bars and sections.*)

Boël, Usines Gustave, Soc. An., La Louvière. (*Ingots, forgings, castings, plates and bars.*)

Boom, Travaux Métalliques de, Société Anonyme, Boom. (*Small castings.*)

Charleroi, Société Anonyme de la Fabrique de Fer de, Charleroi. (*Ingots, slabs and plates.*)

Clabecq, Société Anonyme Forges de, Clabecq, Belgium. (*Ingots, plates, bars and sections.*)

Cockerill-Ougrée, Société Anonyme, Seraing, Belgium.
Works: Division Centre. (*Ingots, blooms, billets, slabs and plates.*)
Works: Division Ouest. (*Ingots, blooms, billets, plates, sections, castings and forgings.*)

Compagnie Générale des Aciers, Société Anonyme, Thy-le-Château, Belgium. (*Castings.*)

Antwerp—*continued*

Esperance Longdoz S.A., Liége, Belgium. (*Ingots and thin plates.*)

Hainaut-Sambre, Société Métallurgiques, S.A., Couillet.
Division de Couillet. (*Ingots, blooms, bars, forgings and castings.*)
Division de Montignies et Chatelinlau. (*Rolling mill.*)

Haine St. Pierre et Lesquin, Aciéries de, Société Anonyme, Haine St. Pierre. (*Castings.*)

Henricot, Usines Emile, Court St. Etienne. (*Castings.*)

Jadot, Société Anonyme Etablissements, Beloeil, Belgium. (*Small castings.*)

Jemappes, Société Anonyme Forges et Laminoirs de, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*)

Leonard-Giot, Société Anonyme Usines & Aciéries Marchienne-au-Pont. (*Castings.*)

Meuse, Les Acieries de la, S.A., Cheratte-lez-Liege, Belgium. (*Castings.*)

Meuse, Les Usines à Tubes de la, Flémalle-Haute, Belgium. (*Seamless tubes.*)

Providence, Société Anonyme des Forges de la, Marchienne-au-Pont, Belgium. (*Sections, bars, ingots and blooms.*)

Sambre, Aciéries & Minières de la.
Works : Monceau-sur-Sambre. (*Sections, bars, billets and blooms.*)
Works : Moncheret, near Acoz. (*Rolling mills for bars.*)

Société Belge Griffin S.A., Merxem, Antwerp. (*Castings.*)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi. (*Castings.*)

Augsburg

Decker, Gebrüder, Betrieb 1, Eisen- & Stahlgiesserei, Nürnberg 2, Ostendstr. 84. (*Electric steel castings.*)

Krauss-Maffei, A.G., München-Allach, Germany. (*Castings.*)

Maximilianshütte, Eisenwerk-Gesellschaft m.b.H., Sulzbach-Rosenberg, Bavaria, Germany.
Haidhof Works. (*Ingots, billets, bars, small sections and thin plates.*)
Rosenberg Works. (*Ingots and billets.*)

Streicher, M., Asperg/Württ, near Stuttgart, Germany. (*Castings.*)

Baltimore, Md.

Bethlehem Steel Co., Sparrows Point, Md., U.S.A. (*Plates.*)

Barcelona

Funderia S.A. de, Manresa, Spain. (*Castings.*)

Fundiciones Escora S.A., Pi y Margall, 2-Hospitalet de Llobregat, Barcelona, Spain. (*Castings.*)

Hierros y Aceros Industriales S.A., San Adrian de Besos, Barcelona, Spain. (*Small castings.*)

Industrias Mecanicas, Sociedad Anonima, Barcelona, Spain. (*Castings.*)

Manufacturas de Acero S.A., Badalona, Barcelona, Spain. (*Small castings.*)

Material y Construcciones S.A., Barcelona, Spain. (*Castings.*)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Castings.*)

Bergen

Stavanger Electro-Staalverk A.S., Jorpeland, near Stavanger, Norway. (*Castings.*)

Berlin

Borsig A.G., Berlin-Tegel, Germany. (*Ingots, forgings and castings.*)

Bilbao

Acerias y Forjas de Azciotia, Azciotia Juipuzcoa, Spain. (*Ingots and small rolled bars.*)

Aceros y Fundiciones del Norte Pedro Orbegozo y Cia. S.A., Hernani (Guipuzcoa), Spain. (*Ingots and forgings.*)

Amurrio, S.A., Talleres de, Amurrio, Alava, Spain. (*Steel castings.*)

Babcock & Wilcox, Sociedad Española de Construcciones.
Head Office: Calle Ercilla 1, Bilbao.
Works: Galindo-San Salvador del Valle. (Vizcaya.) (*Castings, ingots and forgings.*)

Basconia, Compañia Anonima, Bilbao, Spain. (*Plates, sections and bars.*)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small castings and forgings.*)

Crane-Fisa S.A., Bilbao, Spain. (*Small castings.*)

Deusto, S.A. Talleres de, Luchana, Bilbao, Spain. (*Ingots, castings and small forgings.*)

Echevarria, Sociedad Anonima, Bilbao, Spain. (*Small sections and bars, small forgings and ingots.*)

Echeverria, Patricio, S.A., Legazpia, Spain. (*Ingots, blooms, forgings and small bars.*)

Electrodos y Aceros S.A., Boõ, Santander, Spain. (*Castings.*)

Española de Construccion Naval, Sociedad.
Works: Reinosa, near Santander, Spain. (*Ingots, forgings, castings, plates and sections.*)
Works: Sesto, near Bilbao. (*Small castings, ingots and forgings.*)

Euskalduna Compania Fundicion de Asua, (Near Bilbao) Vizcaya, Spain. (*Castings.*)

Fabricaciones Metalurgicas, S.A., "Famesa" Arran Cudiaga, Vizcaya, Spain. (*Ingots and rolled bars.*)

Forjas Alavesas, S.A., Vitoria, Spain. (*Ingots, rolled bars and forgings.*)

Fundiciones Echevarria S.A., Beasain, Guipuzcoa, (*Ingots, small rolled bars and castings.*)

Bilbao—*continued*

Llodio, Aceros de, Ltda., Llodio, near Bilbao, Spain. (*Small castings, ingots, forgings and rolled bars.*)

Luzuriaga, Victorio, S.A., Pasajes, Guipuzcoa, Spain.
Works: Lasarte, Nr. San Sebastian, Guipuzcoa. (*Castings.*)

Nueva Montana Quijano S.A., Nueva Montana, Santander, Spain. (*Castings.*)

Olarra S.A.
Works: Erandio, Bilbao, Spain. (*Ingots and small bars.*)
Works: Larrendo, Lujna, Vizcaya, Spain. (*Ingots and rolled bars.*)

Sifema S.A. Bilbao. (*Steel castings.*)

Vizcaya, Sociedad Altos Hornos de, Bilbao, Spain. (*Ingots, bars, sections, plates and forgings.*)

Bombay

Mukand Iron & Steel Works, Ltd., Kurla, Bombay 70, India. (*Castings.*)

Bordeaux

Société Anonyme d'Exploitation des Aciéries de Bordeaux, Pessac, Gironde, France. (*Castings.*)

Sud Ouest, Société des Forges et Aciéries du, Bordeaux (Gironde), France. (*Castings and forgings.*)

Bremen

Klöckner-Werke A.G., Hutte Bremen, Germany. (*Plates.*)

Brisbane

Bradford Kendall Ltd., Runcorn, Brisbane, Queensland. (*Castings.*)

Walkers Ltd., Maryborough, Queensland, Australia. (*Forgings and castings.*)

Buenos Aires

Astilleros Rio Santiago, Ensenada, Buenos Aires, Argentina. (*Steel castings.*)

Cadiz

Española de Construccion Naval, Sociedad, San Carlos Factory, San Fernando, Cadiz, Spain. (*Forgings and castings.*)

Calcutta

Bhartia Electric Steel Co., Ltd., Calcutta, India. (*Castings.*)

Burn & Co., Ltd., Howrah, India. (*Castings.*)

Hindustan Steel Ltd.,
Rourkela, Orissa, India. (*Ingots, slabs and plates.*)
Durgapur Steel Plant, West Bengal, India. (*Blooms, billets, bars and sections.*)
Bhilai Steel Project, Bhilai, Madhya Pradesh, India. (*Ingots, blooms, billets and sections.*)

Indian Iron & Steel Co., Ltd.,
Burnpur Works, Burnpur, West Bengal, India. (*Sections and angles.*)
Kulti Iron Works, Kulti, India. (*Castings.*)

Calcutta—*continued*

Indian Tube Company, (1953) Ltd., Jamshedpur, India. (*Seamless tubes.*)

Metal & Steel Factory, Ishapore, West Bengal, India. (*Ingots, blooms, billets, forgings and castings.*)

National Iron & Steel Co., Ltd., Stephen House, Calcutta, 1, India. (*Castings.*)

Tata Engineering & Locomotive Co., Ltd., Jamshedpur 4, India. (*Castings.*)

Tata Iron & Steel Co., Ltd., Jamshedpur, India. (*Blooms, billets, bars, plates and sections.*)

Chicago

Bethlehem Steel Co., Burns Harbour Plant, Chesterton, Indiana, U.S.A. (*Rolling mill for plates.*)

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A., (*Ingots, bars and small sections.*)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Castings.*)

Finkl, A, & Sons Company, Chicago, Illinois, U.S.A. (*Forgings.*)

Granite City Steel Co., Granite City, Illinois, U.S.A.

Inland Steel Co., Indiana Harbour, Indiana, U.S.A. (*Ingots, blooms, billets and slabs.*)

Republic Steel Corporation, Chicago Plant, Chicago, Illinois, U.S.A.
Works: 118th Street, Chicago Rolling Mills, East Chicago, Ind., (*Angles and bars.*)

U.S. Steel Co., Pittsburgh, Pa., U.S.A.
Gary Works, Gary Ind. (*Billets, blooms, plates, sections, bars and forgings.*)
South Works, South Chicago, Illinois, (*Plates, sections and bars.*)

Cleveland, O.

Alco Products, Inc., Latrobe, Pa., U.S.A. (*Ingots and forgings.*)

American Rolling Mill Co., Middletown, O., U.S.A. (*Castings and forgings.*)

Bethlehem Steel Co., Lackawanna, N.Y., U.S.A.
Johnstown Plant, Johnstown, Pa., U.S.A.

Crucible Steel Company of America, 4, Gateway Center, P.O. Box 88, Pittsburgh 30, Pa., U.S.A.
Midland Plant, Midland, Pa., (*Ingots, slabs, billets, universal mill plates, hot rolled and cold drawn bars.*)

Erie Forge Co., Erie, Pa., U.S.A. (*Ingots, forgings and castings.*)

Great Lakes Steel Corporation, Division of National Steel Corporation, Ecorse, Detroit 29, Michigan, U.S.A. (*Ingots, billets, bars, slabs, plate, blooms, sheet and coiled strip.*)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A.

National Castings Div., Midland Ross Corp., Sharon, Pa., U.S.A. (*Castings.*)

Cleveland, O.—*continued*

National Forge Co., Irvine, Warren County, Pennsylvania, U.S.A. (*Ingots and forgings.*)

Ohio Steel Foundry Co., Lima, Ohio, U.S.A. (*Ingots, forgings and castings.*)

Pittsburgh Steel Company, Pittsburgh 30, Pa., U.S.A.
Works: Monessen, Pa. (*Ingots, billets and slabs.*)
Works: Allenport, Pa. (*Rolling mills.*)

Republic Steel Corporation, Cleveland, O., U.S.A.
Buffalo Plant, Buffalo, N.Y., U.S.A.
Central Alloy District, Massillon Plant, Massillon, O., U.S.A.
Cleveland District, Cleveland, O., U.S.A.
Corrigan McKinney Plant. (*Ingots, blooms and billets.*)
Upson Nut Plant. (*Round and square bars.*)
Youngstown District, Youngstown, O. U.S.A.

Sharon Steel Corporation, Roemer Works, Farrell, Pa., U.S.A., (*Ingots, blooms, billets, narrow plates and sections.*)

United States Steel Corporation, Pittsburgh, Pa., U.S.A.
Clairton Works, Clairton, Pa. (*Ingots, blooms, bars and sections.*)
Duquesne Works, Duquesne, Pa. (*Ingots, billets, blooms and bars.*)
Homestead District Works, Pa., (including McKees Rock Works.) (*Ingots, billets, blooms, slabs, plates, sections and forgings.*)
Irvin Works, Dravosburg, Pa. (*Rolling mills for thin plates.*)
McDonald Mills, Youngstown. (*Rolling mills for bars and sections.*)
Ohio Works, Youngstown. (*Ingots, billets and blooms.*)

Youngstown Sheet and Tube Company, Brier Hill Works, Youngstown, Ohio, U.S.A.
Campbell Works, Campbell, Mahoning Co., Ohio. (*Ingots and plates up to 12,5 mm. in thickness.*)

Cologne (Köln)

Breitenbach, Ed., G.m.b.H., Weidenau-Sieg, Germany. (*Castings.*)

Eschweiler Bergwerks-Verein Hüttenbetriebe, Eschweiler-Aue, Germany. (*Ingots and seamless tubes.*)

Gussstahlwerke Risch K.G., Bergisch-Gladbach, Germany. (*Electric steel castings.*)

Hüttenwerke Siegerland A.G., Niederschelden, Germany. (*Ingots and slabs.*)

Klockner-Werke A.G., Mannstaedt-Werke, Troisdorf, Germany. (*Rolling mills for sections.*)

Schmidt & Clemens, Edelstahlwerk, Bergausen b/Engelskirchen Bez. Köln, Germany. (*Ingots, forgings, castings and bars.*)

Stahlwerke Röchling-Buderus A.G., Wetzlar, Germany. (*Ingots, blooms, billets, bars, forgings and plates.*)

Stahlwerke Südwestfalen, A.G., Werk Geisweid, Geisweid, Kries Siegen, Germany. (*Ingots, bars, billets, thin plates, sheets and coils.*)

Copenhagen

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Ingots, forgings and castings.*)

Danske, (Det), Staalvalsevaerk A/S., Frederiksvaerk, Denmark. (*Plates, sections and bars.*)

Frichs A/S, Aarhus, Denmark. (*Castings.*)

Helsingors Skibsvaerft-og Maskinbyggeri A/S., Aktieselskabet, Elsinore, Denmark. (*Ingots, forgings and castings.*)

Dortmund

Deutsche Gerätebau G.m.b.H., Werk Stahl u. Eisengiesserei Schubeis, Schwelm, Germany. (*Castings.*)

Edelstahlwerk Witten A.G., Witten-Ruhr, Germany. (*Ingots, billets, sections, bars and forgings.*)

Eisenwerk Geweke, R. & C. R. Lange K.G., Hagen-Haspe, Germany. (*Electric steel castings.*)

Eisenwerk Rödinghausen K. G., Lendringsen Krs. Iserlohn, Germany. (*Castings.*)

Gussstahlwerk Carl Bönnhoff, Wetter/Ruhr, Germany. (*Castings.*)

Gussstahlwerk Wittman A.G., Hagen-Haspe, Germany. (*Castings.*)

Hoesch A.G., Hüttenwerke, Dortmund, Germany.
- Phoenix Hörde Works, Dortmund-Hörde. (*Ingots, plates and castings.*)
- Union Works, Dortmund. (*Bars, sections and forgings.*)
- Westfalenhütte Works, Dortmund. (*Ingots, billets, plates, bars and sections.*)

Klöckner-Werke A.G., Hütte-Haspe, Hagen Haspe, Germany. (*Ingots, plates, bars and sections.*)

Knorr-Bremse G.m.b.H., Volmarstein-Schmandbruch, Germany. (*Castings.*)

Paderwerk Gebr. Benteler, Schlossneuhaus, Germany. (*Seamless tubes.*)

Rheinstahl Hüttenwerke A.G., Werk Ruhrstahl Henrichshütte, Hattingen, Germany. (*Ingots, plates, forgings and castings.*)

Schutte, Meyer & Co., G.m.b.H., Letmathe, Westphalia, Germany. (*Small castings.*)

Stahlwerk Mark Wengern A.G., Wengern-Ruhr, Germany. (*Ingots and castings.*)

Stahlwerke Südwestfalen A.G., Werk Harkort Eicken, Hagen, Germany. (*Ingots, bars and forgings.*)

Dunkerque

Union Siderurgique du Nord de la France, Usine de Dunkerque, Dunkerque (Nord), France. (*Ingots and plates.*)

Durban

Mangolds Engineering, Port Elizabeth, South Africa. (*Small castings.*)

Dusseldorf

August Thyssen-Hütte A.G., Duisburg-Hamborn, Germany. (*Ingots, billets, sections, bars and thin plates.*)

Bergische Stahlindustrie K.G., Remscheid, Germany. (*Castings.*)

Deutsche Edelstahlwerke A.G., Krefeld, Germany. (*Ingots, castings, forgings and rolled materials.*)

Fried. Krupp Huttenwerke A.G. Gussstahlwerk Bochumer Verein, Bochum, Germany. (*Ingots, forgings, castings and bars.*)

Fried. Krupp Huttenwerke A.G. Huttenwerke Rheinhausen, Rheinhausen, Germany. (*Bars and sections only.*)

Gussstahlwerk Oberkassel A.G., Düsseldorf-Oberkassel, Germany. (*Castings.*)

Gutehoffnungshütte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade, Germany. (*Forgings.*)

Hüttenwerk Oberhausen, A.G., Oberhausen, Germany. (*Ingots, plates, sections and bars.*)

Mannesmann A.G.,
- Hahn'sche Werke, Duisburg-Grossenbaum, Germany. (*Bars and electric resistance welded tubes.*)
- Huttenwerk Huckingen, Duisburg-Huckingen, Germany. (*Ingots, plates, sections and bars.*)

Thyssen-Röhrenwerke A.G., Mulheim (Ruhr), Germany. (*Plates.*)

Rheinstahl Hüttenwerke A.G.,
- Werk Friedrich Wilhelms-Hütte, Mülheim und Meiderich, Germany. (*Castings.*)
- Werk Schalker Verein, Gelsenkirchen, Germany. (*Castings.*)

Stahl- u. Röhrenwerke Reisholz G.m.b.H.,
- Works at Reisholz. (*Ingots and seamless tubes.*)
- Works at Oberbilk. (*Forgings.*)

Stahlwerke Bochum A.G., Bochum, Germany. (*Castings, forgings, rolled materials and plates.*)

El Ferrol

Aceros del Zarzo S.A. (Adeza) Cabanas Puentedeume (La Coruna), Spain. (*Ingots and small castings.*)

Astilleros y Talleres del Noroeste S.A., El Ferrol del Caudillo, Spain. (*Small forgings and small castings.*)

Empresa Nacional Bazan, El Ferrol del Caudillo, Spain. (*Castings*).

Emden

Sande, Giesserei, Sande-Oldenburg, Germany. (*Castings.*)

Fremantle

Broken Hill Proprietary Co., Ltd., Rolling Mill at Kwinana, W. Australia. (*Small bars and sections.*)

Hadfields (W.A.) 1934 Ltd., Perth, W. Australia. (*Castings.*)

Gdansk

Huta Z.M.G.S., Elblag, Poland. (*Castings.*)

Zaklady Metalurgiczne Poznan, "Pomet", Poznan ul Krancowa 15, Poland. (*Castings.*)

Genoa

A.S.S.A. Acciaierie di Susa Società Anonima, Turin, Italy. *Head Office:* Turin. *Works:* Susa. (*Castings.*)

Ansaldo S.p.A., Stabilimento Fonderia di Ghisa e Metalli, Genova-Pegli, Italy. (*Forgings.*)

Cantieri del Tirreno, S.p.A., Riva Trigoso, Genoa, Italy. (*Small forgings.*)

Fabrica Italiana Tubi, Società per Azioni, Sestri-Levante, Italy. (*Ingots, billets and weldless rolled and drawn tubes.*)

FIAT, Società per Azioni, Sezione Ferriere Piemontesi, Turin, Italy. (*Ingots, plates, sections; also seamless and welded tubes.*)

FIAT, Società per Azioni, Sezione Industrie Metallurgiche Acciaierie, Turin, Italy. (*Castings.*)

Fonderia Acciaieria Giovanni Mandelli, Turin, Italy. (*Castings.*)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A. *Head Office:* Via Corsica 4, Genoa, Italy.

S.I.A.C., Genoa. (*Ingots, forgings, plates and castings.*)

Stabilimento Oscar Sinigaglia, Genova-Cornigliano. (*Ingots, slabs and plates.*)

Nazionale "Cogne", S.p.A. *Head Office:* Turin, Italy. *Works:* Aosta. (*Ingots, forgings, plates, sections and bars.*)

Gijon

Aceros de Galicia, Vigo, Spain. (*Castings.*)

Duro-Felguera, Sociedad Metalúrgica, La Felguera, Asturias, Spain. (*Castings.*)

Empresa Nacional Siderurgica, S.A. (ENSIDESA), Avilés, Spain. (*Ingots, slabs and billets for re-rolling, plates and sections.*)

"Santa Barbara", Sociedad Industrial Asturiana, Gijon, Spain. (*Forgings.*)

Trubia, Fábrica Nacional de, Trubia Asturias, Spain. (*Castings and forgings.*)

Union de Siderurgicas, Asturianas, S.A. (UNINSA)

Fabrica de Mieres, Asturias, Spain. (*Sections, bars and plates up to 15 mm. in thickness.*)

Fabrica de Gijon, Gijon, Spain. (*Rivet bars and castings.*)

Fabrica de La Felguera, La Felguera, Asturias, Spain. (*Ingots, billets, plates and sections.*)

Gothenburg

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Ingots and forgings.*)

Bofors Aktiebolaget, Bofors, Sweden. (*Ingots, forgings, castings and rolled bars.*)

Gothenburg—*continued*

Klafreströms Bruk, A/B, Klavreström, Sweden. (*Small castings.*)

Lesjöfors Aktiebolag, Lesjöfors, Sweden. (*Ingots and bars.*)

Motala Verkstad, A/B, Motala Verkstad, Sweden. (*Ingots, forgings, castings, sections and bars.*)

Stridsberg & Biorck, A.B., Trollhattan, Sweden. (*Castings.*)

Svenska Kullagerfabriken A/B, Hellefors Jernverk, Hällefors, Sweden. (*Ingots and bars.*)

Uddeholms Aktiebolag, Uddeholm, Sweden.

Works at Degerfors. (*Ingots, plates, sections and bars.*)
Works at Hagfors. (*Castings.*)
Works at Nykroppa. (*Ingots.*)
Works at Storfors. (*Seamless tubes.*)

Halifax, N.S.

Dosco Steel Ltd., Sydney Works, Sydney, N.S. (*Ingots, billets and sections.*)

Hawker Siddeley Canada Ltd., Trenton Works, Trenton, N.S. (*Forgings.*)

Maritime Steel and Foundries, Ltd., New Glasgow, N.S. (*Small castings.*)

Hamburg

Ellerbrock, Hans, Stahlgiesserei und Maschinenfabrik, Hamburg, Germany. (*Castings.*)

Hannover

Eisen-und Stahlwerk Pleissner G.m.b.H., Herzberg/Harz, Germany. (*Castings.*)

Friedrich-Carl-Hutte G.m.b.H., Delligsen über Alfeld/Leine, Germany. (*Castings.*)

Ilseder Hütte/Peine, Stahl- und Walzwerke, Peine, Germany. (*Ingots, billets, sections and bars.*)

Klöckner - Werke A.G. Georgsmarienwerke, Osnabrück, Germany. (*Ingots, bars, forgings and castings.*)

Lindener Eisen-und Stahlwerke G.m.b.H., Hannover-Linden, Germany. (*Ingots and castings.*)

MIAG (Mühlenbau und Industrie G.m.b.H.), Braunschweig, Germany. (*Castings.*)

Salzgitter Hüttenwerk A.G., Salzgitter-Drütte, Germany. (*Ingots, plates, bars and sections.*)

Sollinger Hütte G.m.b.H., Uslar/Solling, Germany. (*Castings.*)

Tweer, Reinhard, G.m.b.H., Brackwede/Westf., Germany. *Works:* Kracks near Bielefeld. (*Castings.*)

Helsingfors

Ahlström, A., Oy, Karhulan Tehtaat, Karhula Bruk, Karhula, Finland. (*Castings.*)

Stenberg, Oy John, A.B., Helsingfors, Finland. (*Small castings.*)

Vuoksenniska Oy, Aktiebolag, Imatra Steel Works, Imatra, Finland. (*Ingots, slabs, blooms and billets, bars, sections and castings.*)

Hiroshima

Kobe Steel Ltd., Kure Works, Kure, Japan. (*Ingots, Castings and small forgings.*)

Kotobuki Kogyo Co., Ltd., Hiro Works, Kure, Japan. (*Castings.*)

Istanbul

Makine ve Kimya Endustri, Celik Fabrikasi, Kirikkale, Turkey. (*Ingots, forgings, rolled sections and bars.*)

Turkiye Demir ve Celik Isletmeleri, Karabuk, Turkey. (*Ingots, thin plates, rolled sections and bars.*)

Katowice

Huta 1-Maja, Gliwice, Poland. (*Forgings.*)

Huta Baildon, Katowice, Poland. (*Ingots, forgings and bars.*)

Huta Batory, Chorzow-Batory, Poland. (*Forgings, plates and tubes.*)

Huta Bierut, Czestochowa, Poland. (*Seamless tubes.*)

Huta Bobreck, Bytom, Poland. (*Ingots, slabs and blooms.*)

Huta im M. Buczka, Sosnowiec, Poland. (*Seamless tubes.*)

Huta Dzierzynski, Dabrowa Gornicza, Poland. (*Billets, sections and bars.*)

Huta Florian, Swietochlowice, Poland. (*Angles and bars.*)

Huta Jednosc, Siemianowice Slaskie, Poland. (*Ingots and seamless tubes.*)

Huta Kosciuszko, Chorzow, Poland. (*Billets, blooms, sections and rivet bars.*)

Huta Labedy, Labedy, Poland. (*Flats and sections.*)

Huta im. Lenina, Krakow, Poland. (*Ingots, slabs, plates up to 12 mm.*)

Huta Malapanew, Ozimek k/Opola, Poland. (*Castings.*)

Huta Nowotko, Ostrowiec Swietokrzyski, Poland. (*Sections.*)

Huta Pokoj, Ruda Slaska, Poland. (*Plates and sections.*)

Huta Stalowa Wola, Stalowa Wola, Poland. (*Castings, forgings, plates and sections.*)

Huta Zawiercie, Zawiercie, Poland. (*Flats and bars.*)

Zaklady Budowy Przewodow i Armatury, Kielce, Poland. (*Castings.*)

Zaklady Urzadzen Technicznych "Zgoda", Swietochlowice, Poland. (*Forgings.*)

Kiel

Nordische Stahlwerke, Bach & Co., Neumünster, Germany. (*Castings.*)

Kobe

Aichi Steel Works Ltd.

Chita Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*)

Kariya Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*)

Kobe—*continued*

Chubu Steel Plate Co., Ltd., Nakagawa Works, Nagoya, Japan. (*Ingots and plates.*)

Daido Steel Co., Ltd.

Chita Plant, Nagoya, Aichi Prefecture, Japan. (*Ingots, billets and bars.*)

Hoshizaki Works, Nagoya, Japan. (*Ingots and bars.*)

Tsukiji Works, Nagoya, Japan. (*Ingots, forgings and castings.*)

Daitetsu Steel Industrial Co., Ltd., Osaka, Japan. (*Ingots and sections.*)

Endo Iron Works Co., Ltd., Osaka, Japan. (*Forgings.*)

Fuji Iron & Steel Co., Ltd., Hirohata Works, Hirohata, Himeji City, Japan. (*Ingots, billets, plates and sections.*)

Fujinagata Shipbuilding & Engineering Co., Ltd., Osaka, Japan. (*Forgings.*)

Go Iron Works, Ltd., Tarui Works, Tarui, Japan. (*Small castings.*)

Hitachi Metal Industries Ltd., Yasugi Works, Yasugi, Japan. (*Ingots, bars and forgings.*)

Hitachi Shipbuilding & Engineering Co., Ltd.

Chikko Shipyard, Osaka, Japan. (*Castings and forgings.*)

Innoshima Shipyard, Innoshima, Japan. (*Forgings and small castings.*)

Howa Machinery, Ltd., Inazawa Plant, Aichi Prefecture, Japan. (*Castings.*)

Ishikawajima-Harima Heavy Industries Co., Ltd., Aioi Works, Aioi, Japan. (*Castings and forgings.*)

Izuo Chukosho Co., Ltd., Osaka, Japan. (*Castings.*)

Kansai Steel Corp., Sakai, Japan. (*Ingots, bars and flat bars.*)

Kansai Tekko Co., Ltd., Amagasaki, Japan. (*Small forgings.*)

Kawasaki Dockyard Co., Ltd., Kobe, Japan. (*Castings.*)

Kawasaki Rolling Stock Mfg. Co., Ltd., Kobe, Japan. (*Castings.*)

Kawasaki Steel Corporation.

Chita Works, Handa City, Japan. (*Ingots and castings.*)

Fukiai Works, Kobe, Japan. (*Blooms, sections and plates.*)

Hyogo Works, Kobe, Japan. (*Castings and forgings.*)

Mizushima Works, Mizushima, Japan. (*Rolling mill for bars.*)

Nishinomiya Works, Nishinomiya, Japan. (*Ingots and thin plates.*)

Kinka Kikai Co., Ltd., Gifu, Japan. (*Castings.*)

Kobe Steel Ltd.

Works: Amagasaki, Japan. (*Ingots, plates, sections and bars.*)

Works: Kobe, Japan. (*Ingots, blooms, billets, bars and castings.*)

Works: Takasago, Japan. (*Ingots, forgings and castings.*)

Kobe—*continued*

Kokko Steel Works, Ltd., Osaka, Japan. (*Angles, bars and castings.*)

Kokoku Chuko-sho K.K., Osaka, Japan. (*Castings.*)

Komatsu Manufacturing Co., Ltd.
- Komatsu, Japan. (*Castings.*)
- Osaka Plant, Hirakata, Osaka Prefecture, Japan. (*Castings.*)

Kubota Iron & Machinery Works, Ltd., Hirakata Plant, Hirakata, Osaka, Japan. (*Castings.*)

Kureha Seiko Co., Ltd., No. 1, 5-Chome Takeshima-Cho, Nishiyodogawa-Ku, Osaka, Japan. (*Castings.*)

Kurimoto Iron Works Ltd., Kagaya Works, Osaka, Japan. (*Castings.*)

Maekawa Electric Steel Castings Co., Osaka, Japan. (*Castings.*)

Maizuru Shipbuilding & Eng. Co., Ltd., Maizuru Shipyard, Maizuru, Japan. (*Small forgings and castings.*)

Mitsubishi Heavy Industries Ltd.
- Kobe Shipyard & Engine Works, Kobe, Japan. (*Ingots and small forgings.*)
- Mihara Machinery Works, Mihara, Japan. (*Castings and forgings.*)
- Takasago Machinery Works, Takasago, Japan. (*Forgings.*)

Mitsui Shipbuilding & Engineering Co., Ltd., Tamano, Japan. (*Ingots, forgings and castings.*)

Mitsumoto Valve Manufacturing Co., Ltd., Domyoji, Osaka, Japan. (*Small forgings and small castings.*)

Nakayama Steel Works, Osaka, Japan. (*Ingots and plates.*)

Nippon Sharyo Seizo Kaisha Ltd., Nagoya, Japan. (*Castings.*)

Nippon Steel Foundry Co., Ltd., Osaka, Japan. (*Castings.*)

Nippon Tanko Co., Ltd., Amagasaki, Japan. (*Small forgings.*)

Nisshin Seiko Co., Ltd., Shikama Plant, Himeji, Japan. (*Rolled bars.*)

Ohtani Heavy Industrial Co., Ltd.
- Amagasaki Plant, Amagasaki, Japan. (*Plates up to 12,5 mm. in thickness.*)

Okamoto Iron Works Co., Kobe, Japan. (*Forgings.*)

Onomichi Anchor Manufacturing Co., Ltd., Onomichi, Japan. (*Castings.*)

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka, Japan. (*Small castings.*)

Osaka Steel Casting Co., Ltd., Osaka, Japan. (*Small castings.*)

Otani Steel Works Ltd., Osaka, Japan. (*Ingots and plates.*)

Rikimi Cast Steel Co. Ltd., Osaka, Japan. (*Small castings.*)

Sanyo Special Steel Co. Ltd., Himeji, Japan. (*Ingots, forgings and rolled bars.*)

Seo Koatsu Kogyo Co., Ltd., Osaka, Japan. (*Small forgings.*)

Kobe—*continued*

Sumitomo Electric Industries, Ltd., Itami Works, Itami, Hyogo Prefecture, Japan. (*Ingots and small bars.*)

Sumitomo Machinery Co., Ltd., Niihama, Japan. (*Castings.*)

Sumitomo Metal Industries, Ltd.
- Osaka Steel Works, Osaka, Japan. (*Castings, forgings and bars.*)
- Steel Tube Works, Amagasaki, Japan. (*Ingots, forgings, small bars, sections and weldless tubes.*)
- Wakayama Steel Works, Wakayama, Japan. (*Ingots, plates, seamless tubes and electric resistance welded tubes.*)

Takada Steel Works, Ltd., Takada City, Nara Prefecture, Japan. (*Castings.*)

Teikoku Kokan Seizosho K.K., Osaka, Japan. (*Seamless tubes.*)

Topy Industries Ltd., Toyohashi Works, Toyohashi, Japan. (*Ingots, sections and flat bars.*)

Toyo Kikai-Kinzoku Co., Ltd., Tsuchiyama Plant, Akashi, Japan. (*Small castings.*)

Washino Machine Co., Ltd., Imamura Plant, Aichi Prefecture, Japan. (*Castings.*)

Yamato Steel Works, Ltd., Osaka, Japan. (*Ingots, sections and plates.*)

Yawata Iron & Steel Co., Ltd., Sakai Works, Sakai Osaka, Japan. (*Ingots and sections.*)

Yonago Steel Works, Ltd., Yonago, Japan. (*Castings.*)

La Spezia

Faggian, Acciaierie Elettriche Pio, Soc. per Azioni, La Spezia, Italy. (*Small castings.*)

Leghorn

"ITALSIDER" Alti Forni e Acciaierie Ruinite Ilva e Cornigliano S.p.A., Stabilimento di Portovecchio di Piombino, Italy. (*Ingots, blooms, sections and bars.*)

Lisbon

"COMETNA" Companhia Metalurgica Nacional, S.A.R.L., Amadora, Portugal. (*Castings.*)

Metalurgica Duarte Ferreira S.a.r.l., Tramagal, Portugal. (*Castings.*)

Siderurgia Nacional, S.a.r.l., Seixal, Portugal. (*Sections and bars.*)

União Fabril, Companhia, Barreiro, Portugal. (*Castings.*)

Los Angeles

Bethlehem Steel Co., Los Angeles 54, Cal., U.S.A. (*Round bars.*)

Kaiser Steel Corporation, Fontana, Cal., U.S.A. (*Ingots and plates.*)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Castings.*)

United States Steel Corporation.
- Torrance Works, Torrance, Calif., U.S.A. (*Round bars and sections.*)
- Geneva Works, Provo, Utah, U.S.A. (*Plates.*)

Malmö

Anderson, Aktiebolaget Abjörn, Svedala, near Malmö, Sweden. (*Castings.*)

Kockums Jernverk, Kallinge, Sweden. (*Castings.*)

Mannheim

Dingler, Karcher & Cie., G.m.b.H., Saarländisches Stahlwerk, Worms/Rhein. (*Castings.*)

Schütze-Werke G.m.b.H. Ludwigshafen/Rhein, Germany. (*Electric steel castings.*)

Stahlwerk Mannheim A.G., Mannheim-Rheinau. (*Ingots, forgings and castings.*)

Marseilles

Aciéries du Furan, St. Etienne (Loire), France. (*Electric steel castings.*)

Aubert et Duval, Anciens Ets., Aciéries des Ancizes, Puy de Dôme. (*Ingots, rolled bars and forgings.*)

Compagnie des Ateliers et Forges de la Loire :

Usines de l'Ondaine, Firmigny (Loire), France. (*Ingots, billets, blooms, bars, castings and forgings.*)

Usines de St. Chamond (Loire), France. (*Forgings and plates.*)

Usines de l'Ondaine, Unieux (Loire), France. (*Forgings.*)

Usines de St. Etienne, St. Etienne (Loire), France. (*Plates.*)

Feurs, Fonderies & Acieries Electriques de, Feurs (Loire), France. (*Small castings.*)

d'Imphy, Société Metallurgique, Usine de Pamiers (Ariège), France. (*Castings and forgings.*)

Marrel Frères, Société Anonyme des Etablissements, Usine des Etaings, near Rive-de-Ciers (Loire), France. (*Ingots, forgings, plates and bars.*)

Méridionales, Fonderies, Marseilles, France. (*Castings.*)

Provence, Fonderies et Aciéries de, Marseilles, France. (*Castings.*)

Saut-du-Tarn, Société Anonyme des Forges et Aciéries du, Saint-Juéry (Tarn), France. (*Castings.*)

Tamaris, Société des Ateliers et Fonderies des, Tamaris (Gard), France. (*Castings.*)

Teil, Fonderies et Aciéries du, Usine du Frayol, Le Teil (Ardèche), France. (*Small castings.*)

Temple, Aciéries du, Saint-Michel de Maurienne, (Savoie) France. (*Rolled and forged bars and billets.*)

d'Ugine, Aciéries Electriques. Ugine (Savoie), France. (*Ingots, billets, bars, sections, castings and forgings.*)

Melbourne

Davies & Baird Pty., Ltd., 227 Brunswick Road, Brunswick, Melbourne 10, Australia. (*Castings.*)

Steel Company of Australia, Pty., Ltd., Coburg, Melbourne. (*Castings.*)

Vickers, Ruwolt, Pty., Ltd., Richmond, Melbourne. (*Steel castings and ingots.*)

Metz (*Saarbrücken District*)

de Wendel et Cie., S/A, Hayange, Moselle, France.

Usine de Fenderie. (*Plates.*)

Usine de St. Jaques. (*Sections.*)

Lorraine-Escaut S.A.

Usine de Longwy, Section Mont-St.-Martin, Mont-St.-Martin (Meurthe et Moselle). (*Sections and plates.*)

Usine de Longwy, Section Senelle, Longwy-Bas (Meurthe et Moselle.) (*Ingots, blooms, bars and sections.*)

Usine de Thionville, Thionville (Moselle). (*Forgings.*)

Pompey, Société des Aciéries de, Usine de Pompey, Meurthe et Moselle, France. (*Ingots, blooms, billets, plates, angles and round bars.*)

S.A.F.E., Société des Aciers Fins de l'Est, Hagondange, Moselle, France. (*Ingots, blooms, billets, bars, plates and sheets.*)

Société Lorraine de Laminage Continu, Sollac, B.P.13, Serémange, Moselle, France. (*Ingots, slabs and plates.*)

Société Mosellane de Siderurgie, Hagondange (Moselle), France. (*Blooms, billets, bars and sections.*)

Union Sidérurgique Lorraine, SIDELOR, Usine d'Homécourt, Meurthe et Moselle, France. (*Ingots, blooms, billets and universal flats.*)

Usine de Micheville, Villerupt, Meurthe et Moselle, France. (*Ingots, blooms, billets, bars and sections.*)

Usine de Rombas, Moselle, France. (*Ingots, blooms, billets, bars and sections.*)

Milan

Amsco Italiana S.p.A., Milan. (*Small castings.*)

Breda Fucine, S.p.A., Sesto San Giovanni, Milan. (*Castings and forgings.*)

Breda Siderurgica, S.p.A., Sesto San Giovanni, Milan. (*Ingots and sections.*)

Brescia, Acciaieria e Turbificio di, S.p.A., Brescia. (*Ingots, sections and bars, castings, weldless or water gas welded tubular materials.*)

Caleotto, Acciaieria e Ferriera del, S.p.A., Lecco. (*Ingots, castings, bars, small sections and small forgings.*)

Cantieri Navali Riuniti. *Head Office:* Genoa. *Works:* Cantieri Navale ed Officine Meccaniche di Ancona. (*Small castings.*)

Ceretti, Pietro Maria, S.p.A., Ferriera dell' Ossola-Villadossola. (*Castings.*)

Dalmine, S.p.A. *Head Office:* Milan.

Dalmine Costa Volpino, Bergamo. (*Seamless tubes.*)

Dalmine Works, Bergamo. (*Ingots and seamless tubes.*)

Falck, Acciaierie e Ferriere Lombarde. *Head Office & Works:* Milan. (*Weldless rolled or drawn tubes.*)

Concordia Works, Sesto San Giovanni, Milan. (*Ingots and plates.*)

Unione Works, Sesto San Giovanni, Milan. (*Ingots, sections, bars, forgings and castings.*)

Milan—*continued*

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Stabilimento di Lovere. (*Sections, bars, castings and forgings.*)

Luigi Giudici, Societa per Asioni, Rescaldina, Milan. (*Small castings.*)

Metallurgica Marcora, S.n.C., Busto Arsizio (Varese). (*Weldless rolled and drawn tubes.*)

Pracchi, Fonderie Elettriche O., S.p.A., Milan. (*Small castings.*)

S.I.S.M.A.—Società Industrie Siderurgiche Meccaniche & Affini, Villadossola (Novara). (*Rolled bars and rivets.*)

Società Metallurgica Vittorio Cobianchi S.p.A.
Head Office: Milan.
Works: Omegna (Novara.) (*Castings.*)

Stramezzi, P., & C., Acciaieria e Ferriera di Crema, Crema. (*Ingots, bars, small sections and rivets.*)

Tassara S.A., Carlo, and Metalcam S.p.A., Breno, Brescia, Italy. (*Ingots, bars and small forgings.*)

Tosi, Franco, S.p.A., Legnano. (*Forgings and castings.*)

Villa, Giovanni, S.p.A., Officine Meccaniche-Fucinati-Stampati, Milan. (*Forgings.*)

Mobile, Ala.

Kilby Steel Co., Furnace Division, Anniston, Ala., U.S.A. (*Ingots.*)

Republic Steel Corporation, Alabama City, Ala., U.S.A.

Tennessee Coal & Iron Division, United States Steel Corporation, Birmingham, Ala., U.S.A. *Works:* Ensley, Ala.; *Rolling mills and forgings:* Bessemer and Fairfield, Ala.

Montreal

Canadian Steel Foundries Division Hawker Siddeley Canada, Ltd., Longue Pointe, Montreal, P.Q., Canada. (*Castings.*)

Canadian Unitcast-Steel, Ltd., Sherbrooke, P.Q., Canada. (*Castings.*)

Crucible Steel Company of Canada, Ltd., Sorel, P.Q., Canada. (*Castings.*)

Dominion Steel & Coal Corporation Ltd., Montreal Works, 5870, St. Patrick Street, Montreal, P.Q., Canada. (*Angles, bars and rivets.*)

Lynn Macleod Metallurgy, Ltd., Thetford Mines, P.Q., Canada. (*Castings.*)

Manitoba Rolling Mills Division of Dominion Bridge Co., Ltd., Selkirk, Manitoba, Canada. (*Billets, bars and sections.*)

Sorel Steel Foundries, Ltd., Sorel, P.Q., Canada. (*Castings.*)

Steel Company of Canada, Hamilton, Ontario, Canada. *Works:* Montreal. (*Bars and angles, plates and billets.*)

Nagasaki

Mitsubishi Heavy Industries Ltd., Nagasaki Works, Nagasaki, Japan. (*Castings and small forgings.*)

Mitsubishi Steel Manufacturing Co., Ltd., Nagasaki Works, Nagasaki, Japan. (*Ingots, blooms, plates, forgings and castings.*)

Osaka Steel Tube Co., Ltd., Sasebo Works, Sasebo, Japan. (*Seamless tubes.*)

Sasebo Heavy Industries Co., Ltd., Sasebo, Japan. (*Castings and forgings.*)

Nantes

d'Hennebont, Forges, Hennebont, Morbihan, France. (*Ingots, plates and castings.*)

Marine Nationale Indret, Etablissements de la, Loire-Atlantique, France. (*Castings.*)

Sambre et Meuse, Société Anonyme des Usines & Aciéries de, Usines de Saint Brieuc, Cotes-du-Nord. (*Small castings.*)

Naples

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A.
Stabilimento di Bagnoli. (*Ingots, sections and bars.*)
Stabilimento di Taranto. (*Ingots, slabs and plates.*)

MECFOND-Officine Meccaniche e Fonderie Napoletane, Naples, Italy. (*Castings.*)

Meridionali, Acciaierie e Tubificio, S.p.A., Bari, Italy. (*Castings and weldless rolled or drawn tubes.*)

"Terni" Società per l'Industria e l'Elettricha.
Works: Terni. (*Ingots, forgings, castings and plates.*)

Newcastle, N.S.W.

Broken Hill Proprietary Co., Ltd., Iron and Steel Works, Newcastle, N.S.W. (*Ingots, billets, plates, sections, strip and castings.*)

Commonwealth Steel Co., Ltd., Waratah, Newcastle, N.S.W. (*Castings and forgings.*)

Newport News, Va.

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Castings and forgings.*)

Odense

Varde Staalvaerk, Varde, Denmark. (*Ingots and castings.*)

Oslo

Christiania Spigerverk, Oslo. (*Ingots and bars, also rivet bars.*)

Drammens Jernstoberi & Mek-Verksted, A/S, Drammen. (*Small castings.*)

Norsk Jernverk, A/S, Mo-i-Rana. (*Electric steel ingots, billets, sections and bars.*)

Raufoss Ammunisjonsfabrikker, Raufoss. (*Castings.*)

Strömmens Verksted, A/S, near Oslo. (*Castings.*)

Paris

d'Auxonne, Aciéries & Fonderies, Auxonne (Côte d'Or), France. (*Small castings.*)

"Acieroy" Aciéries et Fonderies du Doubs, Société Anonyme, Sainte-Suzanne, near Montbéliard (Doubs), France. (*Small electric steel castings.*)

Creusot, Société des Forges et Ateliers du (S.F.A.C.), Usines Schneider, Le Creusot, France. (*Ingots, forgings, castings, plates and sections.*)

Ferry-Captain & Cie, Société, Bussy, près Joinville (Haute Marne), France. (*Electric steel castings.*)

Gennevilliers, Aciéries de, Gennevilliers, (Seine), France. (*Castings.*)

Guerigny, Forges Nationales de la Chaussade à (Nièvre), France. (*Ingots, bars, forgings and castings.*)

Geugnon, Forges de, Geugnon, (S. & L.), France. (*Rolling mill for plates.*)

Hachette & Driout, S.A., des Anciens Etablissements St. Dizier, (Haute Marne), France. (*Castings.*)

d'Imphy, Société Metallurgique, Aciéries d'Imphy (Nièvre), France. (*Ingots, forgings, bars and sections.*)

Maitre & Cie, Ets, Colombier-Fontanie (Doubs), France. (*Small castings.*)

Montluçon, Commentry, Societé des Forges et Ateliers de, Usines St. Jacques, Montluçon (Allier), France. (*Castings, ingots, forgings, sheets and sections.*)

Paris-Seine, Fonderies et Aciéries, Usine de la Folie, Avenue de Bobigny, Noisy-le-Sec. (Seine), France. (*Castings.*)

Philadelphia, Pa.

Atlantic Steel Castings Co., The, Chester, Pa., U.S.A. (*Castings.*)

Bethlehem Steel Co., Bethlehem, Pa., U.S.A. (*Ingots, forgings, bars and sections.*)

Lebanon, Pa., U.S.A. (*Rolling mills for bars.*)

Steelton, Pa., U.S.A. (*Castings.*)

Birdsboro Corporation, Birdsboro, Pa., U.S.A. (*Castings.*)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small castings.*)

Donegal Steel Foundry Company, 601, East Market Street, Marietta, Pa., U.S.A. (*Castings.*)

Empire Steel Castings Inc., Reading Pa., U.S.A. (*Castings.*)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small castings.*)

Lukens Steel Company, Coatesville, Pa., U.S.A. (*Plates.*)

Midvale-Heppenstall Company, Nicetown, Philadelphia, Pa., U.S.A. (*Forgings.*)

Penn Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*)

Pennsylvania Forge, Division of Chemetron Corporation, Tacony, Philadelphia 35, Pa., U.S.A. (*Forgings.*)

Pennsylvania Steel Foundry and Machine Company, Hamburg, Pa., U.S.A. (*Castings.*)

Philadelphia, Pa—*continued*

Phoenix Steel Corporation.

Works: Claymont, Delaware, U.S.A. (*Plates.*)

Works: Structural Division, Phoenixville, Pa., U.S.A. (*Sections, bars and rotary forged seamless tubes.*)

Quaker Alloy Casting Co., Myerstown, Pa., U.S.A. (*Small castings.*)

Standard Steel Division of Baldwin-Lima-Hamilton Corp., Burnham, Mifflin County, Pa., U.S.A. (*Castings and forgings.*)

United States Steel Corporation, Fairless Works, Morrisville, Pa., U.S.A. (*Thin plates, bars and sections.*)

Wood, Alan, Steel Company, Conshohocken, Pa., U.S.A. (*Blooms, billets and plates.*)

Piraeus

Nicolacopoulos G., & Co., Athens, Greece, Steelworks at Eleusis. (*Castings.*)

Viomichania Chalyvon Ltd., Athens Greece. (*Castings.*)

Port Kembla

Australian Iron & Steel Pty., Ltd., Port Kembla, N.S.W. (*Plates, bars, sections and forgings.*)

Port Said

Egyptian Iron & Steel Co., S.A.E., Helwan, U.A.R. (*Plates.*)

Rijeka

Tvornica Dizalica I Ljevaonica "Vulkan" Rijeka 11, Yugoslavia. (*Castings.*)

Zelezarna Ravne, Ravne na Koroskem, Yugoslavia. (*Castings, forgings, billets and bars.*)

Zeljezara Sisak, Sisak Predgradje, Yugoslavia. (*Seamless tubes.*)

Rio de Janeiro

Acos Villares S.A., Sao Caetano do Sul, Sao Paulo, Brazil. (*Castings, forgings, billets and bars.*)

Brasileira de Usinas Metalurgicas, The Companhia, Usina de Neves Sao Goncalo, Estado do Rio de Janeiro, Brazil. (*Ingots, sections and bars.*)

Companhia Siderurgica Nacional, Usina Presidente Vargas, Volta Redonda, Estado do Rio de Janeiro, Brazil. (*Plates and sections.*)

Usinas Siderurgicas de Minas Gerais S.A., Belo Horizonte, Estado de Minas Gerais, Brazil.

Works: Ipatinga, Estado de Minas Gerais. (*Ingots, slabs and plates.*)

Rotterdam

Bakker N.V., Machinefabriek-Staalgieterij, Ridderkerk, Holland. (*Ingots and castings.*)

Rotterdamsche Droogdok Maatschappij, Rotterdam, Holland. (*Ingots, forgings and small castings.*)

Rouen

Société des Aciéries de Pompey, Usines du Manoir à Pitres (Eure), France. (*Castings.*)

Société Métallurgique de Normandie, Mondeville, France. (*Ingots, blooms, billets and bars.*)

Saarbrücken-Saar

"ARBED," Aciéries Réunies de Burbach - Eich - Dudelange.

Division de Dommeldange, Dommeldange, Luxembourg. (*Ingots, forgings and castings.*)

Division de Belval, Esch-sur-Allzette, Luxembourg. (*Ingots, blooms, billets, bars and angle bars.*)

Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*)

Division de Burbach, Sarrebruck.

Burbach Works. (*Ingots, billets and sections.*)

Hostenbach Works. (*Plates.*)

Dingler, Karcher & Cie., G.m.b.H., Saarbrücken, Saar. (*Castings.*)

HADIR, Société des Haut-Fourneaux et Aciéries de Differdange - St. Ingbert - Rumelange, Differdange Works, Luxembourg. (*Sections and bars.*)

Neunkircher Eisenwerk A.G. Neunkirchen/Saar.

Neunkirchen Works. (*Ingots, bars and sections.*)

Homburg Works. (*Ingots and seamless tubes.*)

Pohlig-Heckel Bleichert, Vereinigte Maschinenfabriken A.G., Abt. Stahlformgiesserei, Werk Heckel, Rohrbach/Saar, Germany. (*Castings.*)

Röchling'sche Eisen-und Stahlwerke G.m.b.H., Völklingen (Saar). (*Castings, ingots, billets, bars and forgings.*)

Société Anonyme des Forges et Aciéries de Dilling, Dillingen, Sarre. (*Ingots and plates.*)

Wurth, Société Anonyme des Anciens Etablissements Paul, Luxembourg. (*Castings.*)

San Francisco, Cal.

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Castings.*)

General Metals Corporation, Oakland, Cal., U.S.A. (*Castings.*)

Pacific States Steel Corporation, Union City, Cal., U.S.A. (*Ingots, sections and bars.*)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Castings.*)

Santiago

Pacifico, Compania de Acero del, S.A., Talcahuano, Chile. (*Ingots, plates, bars and sections.*)

Seattle, Wash.

Bethlehem Steel Co., Seattle, Wash., U.S.A. (*Sections and bars.*)

Jorgensen, Earle N. Co., Isaacson Division, P.O. Box 3970, Seattle, Wash.

Olympic Steel Works, Seattle, Wash., U.S.A. (*Castings.*)

Washington Iron Works, Seattle, Wash., U.S.A. (*Castings.*)

Shimonoseki

Hitachi Ltd., Kasado Works, Kudamatsu, Japan. (*Castings and forgings.*)

Hitachi Metal Industries Ltd., Tobata Works, Tobata, Japan. (*Castings.*)

Japan Steel Works Ltd., Hiroshima Works, Hiroshima, Japan. (*Forgings and castings.*)

Kure Shipbuilding & Engineering Co., Ltd., Kure, Japan. (*Small forgings.*)

Matsuya Kogyo Co., Ltd., Fukuoka, Japan. (*Small forgings.*)

Mitsubishi Heavy Industries, Ltd., Hiroshima Works, Hiroshima, Japan. (*Ingots, castings and small forgings.*)

Shimonoseki Shipyard & Engine Works, Shimonoseki, Japan. (*Small forgings.*)

Mitsui Miike Machinery Co., Ltd., Miike Works, Omutashi, Japan. (*Castings.*)

Nisshin Steel Works, Ltd., Kure Works, Kure, Japan. (*Ingots, blooms, billets and strip.*)

Okano Valve Manufacturing Co., Ltd., Moji. *Works:* Yukuhashi, Japan. (*Small castings.*)

Ozuki Seikosho Ltd., Shimonoseki, Japan. (*Castings.*)

Sumitomo Metal Industries, Ltd., Kokura Steel Works, Kitakyushu-City, Japan. (*Ingots, billets, bars and sections.*)

Ube Industries, Ltd., Ube Machinery Works, Ube, Japan. (*Ingots, forgings and castings.*)

Wakamatsu Sharyo Co. Ltd., Kitakyushu-City, Japan. (*Small castings.*)

Yawata Iron and Steel Co., Ltd., Yawata Works, Kitakyushu City, Japan.

Tobata Area Works. (*Plates and ingots.*)

Yawata Area Works. (*Plates, sections, ingots and forgings.*)

Split

Titovi Zavodi Litostroj, Ljubljana, Yugoslavia. (*Castings.*)

Zelezarna Jesenice, Jesenice, Yugoslavia. (*Plates, bars, sections and small castings.*)

Zeljezara "Boris Kidric", Niksic, Yugoslavia. (*Plates and castings.*)

Zeljezara Zenica, Zenica, Yugoslavia. (*Billets, bars, sections and forgings.*)

Stockholm

Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Plates, sections and castings; also high pressure air receivers.*)

Boxholms A/B., Boxholm, Sweden. (*Ingots, rolled slabs, blooms, billets, sections and bars.*)

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Bruks-koncernen.)

Works: Fagersta. (*Blooms, billets, forgings, rolled bars and electric resistance welded tubes.*)

Works: Forsbacka. (*Blooms, billets, forged and rolled bars.*)

Works: Horndal. (*Bars and sections.*)

Works: Osterbybruk. (*Castings, forgings and rolling mill for bars.*)

Stockholm—*continued*

Hallstahammar Aktiebolag, Hallstahammar, Sweden. (*Bars.*)

Hults Bruk A.B., Aby, Sweden. (*Castings.*)

Kanthal, A/B, Hallstahammer, Sweden. (*Ingots, billets, bars and castings.*)

Kohlswa Jernverks Aktiebolag. (*Ingots, forgings and castings.*)

Larssons A/B, P. S., Gjuteri & Aduceringsverk, Eskilduna, Sweden. (*Castings.*)

Nordiska Armaturfabrikerna, A/B, Linköping, Sweden. (*Castings.*)

Norrbottens Järnverk Aktiebolag, Lulea, Sweden. (*Ingots, slabs, blooms and billets, bars and sections.*)

Oxelosunds Jarnverk, Oxelosund, Sweden. (*Ingots, rolled slabs and plates.*)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*)

SKF, Hofors Bruk, Hofors, Sweden. (*Billets, bars, forgings and thick walled tubes.*)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Ingots, forgings, and tubes.*)

Smedjebackens Valsverks Aktiebolag, Smedjebacken, Sweden. (*Bars, sections, castings and ingots for re-rolling.*)

Stål och Maskinaktiebolaget, Upsala, Sweden. (*Ingots.*)

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

Works: Domnarfvet. (*Castings, ingots, sections and plates.*)

Works: Söderfors. (*Forgings, bars and sections.*)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Plates, forgings and castings.*)

Svenska Jarnvagsverkstaderna, A/B, Linköping, Sweden. (*Castings.*)

Svenska Kullagerfabriken, Aktiebolaget, Katrineholm, Sweden. (*Castings.*)

Wikmanshytte Bruks A/B, Wikmanshyttan, Sweden. (*Forgings, bars and sections.*)

Sydney, N.S.W.

Bradford, Kendall, Ltd., Alexandria, Sydney, N.S.W. (*Castings.*)

Hadfields Steel Works, Ltd., Alexandria, Sydney, N.S.W. (*Castings and forgings.*)

Industrial Steels, Ltd., Lidcombe, Sydney, N.S.W. (*Castings.*)

Tampico

Altos Hornos de Mexico, S.A., (A.H.M.S.A.), Monclova, Coah., Mexico. (*Plates*).

Fundidora de Fierro y Acero de Monterrey, S.A., Monterrey, N.L., Mexico. (*Plates.*)

Toronto, Ontario

Algoma Steel Corporation, Ltd., Sault St. Marie, Ontario, Canada. (*Billets, bars, angles and plates.*)

Atlas Steels Company, Welland, Ontario, Canada. (*Ingots and bars.*)

Burlington Steel Company, Division of States Steel Industries, Ltd., Hamilton, Ontario, Canada. (*Small sections and bars.*)

Canada Foundries & Forgings, Ltd., Welland, Ontario, Canada. (*Forgings.*)

Dominion Foundries & Steel, Ltd., Hamilton, Ontario, Canada. (*Ingots, plates and castings.*)

Interprovincial Steel and Pipe Corporation Ltd., Regina, Saskatchewan, Canada. (*Plates.*)

Steel Company of Canada, Hamilton, Ontario, Canada. (*Bars and angles, plates and billets.*)

Welmet Industries, Ltd., Welland, Ontario, Canada. (*Small castings.*)

Trieste

F.A.S.E.F., S.p.A., Fonderie Acciaio Scabar e Figli, Porto Industriale, Trieste, Italy. (*Small castings.*)

Bertoli fu Rudolfo, S.p.A., Officine Fratelli, Udine, Italy. (*Castings, forgings, bars and sections.*)

Crane-Orion S.p.A., Porto Industriale, Trieste, Italy. (*Forgings and castings.*)

Gorizia, S.A. Fonderie Officine di, Gorizia, Italy. (*Small castings.*)

S.A.F.A.U. Ferriere Acciaierie di Udine, Udine, Italy. (*Ingots, forgings, blooms, bars and sections.*)

Valencia

"ELCANO", Empresa Nacional, Factoria de Manises, Valencia, Spain. (*Castings and forgings.*)

Vizcaya, Altos Hornos de, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Ingots, plates, bars and sections.*)

Valenciennes

Blanc-Misseron, Société Française des Aciéries de, Quievrechain (Nord), France. (*Ingots and castings.*)

Chiers, Société des Hauts-Fourneaux de la, Forges de Vireux Molhain, Vireux, Ardennes, France. (*Plates, bars and sections.*)

Compagnie des Ateliers et Forges de la Loire, Usine des dunes, Malo les Bains (Nord), France. (*Ingots, billets, blooms, bars and forgings.*)

Constructions Electriques de Jeumont, Forges et Ateliers de, Jeumont (Nord), France. (*Castings.*)

Dembiermont & Cie., Maurice, Hautmont (Nord), France. (*Forgings.*)

Fives-Lille-Cail, Société de.

Usine de Fives, Lille (Nord), France. (*Forgings.*)

Usine de Denain, Denain (Nord), France. (*Castings, ingots, forgings, blooms, bars and sheets.*)

Valenciennes—*continued*

Haine-St.-Pierre et Lesquin, Aciéries de, Société Anonyme, Lesquin-lez-Lille (Nord), France. (*Castings.*)

d'Hirson S.A., Aciéries, Hirson, Aisne, France. (*Castings.*)

Laminoirs, Société Anonyme des, Hauts-Fourneaux, Forges et Fonderies, de la Providence, Hautmont (Nord), France. (*Ingots, plates and sections.*)

Lorraine-Escaut S.A.

Département Tubes, Usine d'Anzin, Anzin (Nord), France. (*Ingots and weldless rolled or drawn tubes.*)

Usine de Sedan, Sedan (Ardennes). (*Plates.*)

Marquise, Usines Métallurgiques de, Rinxent, Pas-de-Calais. (*Castings.*)

Maubeuge, Société Anonyme de la Fabrique de Fer de, Louvroil (Nord). (*Ingots and plates.*)

Meuse, Société Metallurgique de la, Forges et Aciéries de Stenay, Stenay, Meuse. (*Small castings.*)

Paris et d'Outreau, Aciéries de, Société Anonyme, Usine d'Outreau, Pas de Calais. (*Castings.*)

Porter, H. K., (France), Aciéries Division Marpent, Marpent (Nord), France. (*Castings.*)

Sambre et Meuse, Société Anonyme des Usines et Aciéries de, Usines de Feignies, Feignies (Nord). (*Castings.*)

Union Siderurgique du Nord de la France.

Usinor Groupe A.

Usines de Denain, Denain (Nord). (*Ingots, plates, sections and castings.*)

Usinor Groupe B.

Usines de Louvroil-Hautmont, Hautmont (Nord). (*Ingots, bars and sections.*)

Usines de Valenciennes, Valenciennes (Nord). (*Ingots, forgings, blooms, bars and sections.*)

Vallourec, Société, Usine d'Aulnoye, Aulnoye (Nord), France. (*Weldless rolled and drawn tubes.*)

Vancouver, B.C.

A.1. Iron & Steel Foundry Ltd., Vancouver, B.C., Canada. (*Small castings.*)

Canadian Sumner Iron Works Ltd., Vancouver, B.C., Canada. (*Small castings.*)

Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, B.C., Canada. (*Castings.*)

Esco Ltd., Port Coquitlam, B.C., Canada (*Castings.*)

Victoria Machinery Depot Co., Ltd., Victoria, B.C., Canada. (*Castings.*)

Western Canada Steel Ltd., (Vancouver Rolling Mills Ltd.,) Vancouver, B.C., Canada. (*Sections and bars.*)

Venice (Mestre)

Bolzano, S.p.A. Acciaierie di, Bolzano. (*Ingots, billets, bars and forgings.*)

Flag S.p.A., Marcon (Mestre). (*Small castings.*)

Gresele, Acciaierie Valbruna di Ernesto, Vicenza. (*Castings, bars, sections and forgings.*)

Venice—*continued*

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Stabilimento di Marghera. (*Rolling mills for small sections and bars.*)

S.A.F.A.S.—Società Azionaria Fonderia Acciai Speciali, Tavernelle di Altavilla, Vicentina, (Vicenza). (*Castings.*)

Vereeniging

Dunswart Iron & Steel Works, Ltd., Benoni, S. Africa. (*Castings, ingots, billets, and small sections.*)

Scaw Metals, Ltd., Union Junction, Transvaal, S. Africa. (*Rivet bars, small rolled sections and castings.*)

South African Iron & Steel Industrial Corporation, Ltd.

"Iscor" Works, Pretoria, Transvaal, S. Africa. (*Ingots, billets, sections and thin plates up to $\frac{3}{8}$ inch thick.*)

"Iscor" Works, Vanderbijl Park, Transvaal, S. Africa. (*Ingots, billets, slabs and plates.*)

Union Steel Corporation of South Africa, Ltd., "Usco" Steel Works, Vereeniging, Transvaal, S. Africa. (*Ingots, billets, small sections, castings and rivet bars.*)

Vanderbijl Engineering Corporation, Ltd., Vanderbijl Park, Transvaal, S. Africa. (*Castings.*)

Vienna

Works in Austria

Böhler, Gebr., & Co., Aktiengesellschaft, Vienna.

Works: Kapfenberg, Styria. (*Ingots, castings, forgings, bars and plates.*)

Works: Bruckbach, Low Austria. (*Rolling mills for sections and bars.*)

Klinger, Rich., Aktiengesellschaft, Gumpoldskirchen, near Vienna. (*Small castings.*)

Österreichisch-Alpine Montangesellschaft, Vienna.

Works: Donawitz, Styria. (*Sections and strip.*)

Works: Kindberg, Styria. (*Rolling mills for small sections, bars and strip.*)

Works: Traisen, Low Austria. (*Castings.*)

Works: Wördern, Low Austria. (*Ingots.*)

Works: Zeltweg, Styria. (*Forged bars.*)

Schoeller-Bleckmann Stahlwerke A.G., Vienna.

Works: Muerzzuschlag-Hoenigsberg, Styria. (*Bars.*)

Works: Ternitz, Low Austria. (*Castings, forgings and bars.*)

Steirische Gusstahlwerke, A.G., Vienna.

Works: Judenburg, Styria. (*Forgings and bars.*)

Vereinigte Österreichische Eisen-und-Stahlwerke A.G.

Works: Liezen, Styria. (*Ingots for forgings, castings.*)

Works: Linz a.d. Donau, Upper Austria. (*Plates, forgings and castings.*)

Waagner-Biro Aktiengesellschaft, Vienna, Austria.

Works: Werk C., Vienna. (*Castings.*)

Vienna—*continued*

WORKS IN CZECHOSLOVAKIA

Nová hut Klementa Gottwalda, národni podnik (New Metallurgical Works of Klement Gottwald, National Corporation), Ostrava - Kunčice. (*Ingots and forgings.*)

Skoda, Oborový Podnik, Plzeň. (*Castings and forgings.*)

Třinecké železárny velké Říjnové socialistické revoluce, národni podnik (Třinec Iron Works Great Socialistic October Revolution National Corporation), Třinec. (*Ingots, sections, bars and castings.*)

Vítkovické Železárny Klementa Gottwalda, národni podnik (The Vitkovice Steel Works Klement Gottwald, National Corporation), Ostrava 10. (*Castings, forgings, plates, sections, bars and seamless tubes.*)

Zelezárny a drátovny Bohumin, národni podnik (Iron Works & Wire Works Bohumin, National Corporation), Bohumin, Czechoslovakia. (*Small sections and bars.*)

WORKS IN HUNGARY

Ganz-Mavag Mozdony Vagon es Gepgyar, Budapest. (*Castings and forgings.*)

K.G.M. Altalanos Gepipari Igazgatóság, Budapest.
Works: Öntödei Vallalat 1. sz. Gyára, Budapest. (*Castings.*)

K.G.M. Jarmuipari Igazgatóság, Budapest.
Works: Magyar Vagon-és Gépgyár, Györ. (*Castings.*)

K.G.M. Vaskohászati Igazgatóság, Budapest.
Works: Lenin Kohászati Müvek, Miskolc-Diósgyör. (*Ingots, slabs, sections, bars, castings and forgings.*)
Works: Dunai Vasnü, Dunaujváros. (*Ingots, slabs and plates.*)
Works: Dunai Vasmü, Lörinci Hengermüve, Budapest. (*Rolling mill for plates.*)
Works: Ozdi Kohászati, Uzemek, Ozd. (*Ingots, slabs, plates, sections and bars.*)

Whyalla

Broken Hill Proprietary Co., Ltd., Steel Foundry, and Rolling Mill, Whyalla, S. Australia. (*Ingots, castings, bars and sections.*)

Winterthur

Fischer, George, Ltd., Schaffhausen Switzerland. (*Castings.*)

Fonderie de fer et d'Acier Biel, Switzerland. (*Castings.*)

Sulzer Bros. Ltd., Winterthur, Switzerland. (*Castings.*)

Von Roll A.-G., Gerlafingen, Switzerland. (*Ingots, round bars and forgings.*)

Yokohama

Ando Iron Works Co., Ltd., Tokyo, Japan. (*Small forgings.*)

Azuma Steel Works Ltd.
Azuma Plant, Tokyo, Japan. (*Ingots for plate.*)
Senju Plant, Tokyo, Japan. (*Rolling mills for plates.*)

Yokohama—*continued*

Daido Steel Co., Ltd., Shibukawa Works, Shibukawa, Japan. (*Ingots, small forgings and bars.*)

Date Seiko Co., Ltd., Tokyo, Japan. (*Castings.*)

Fuji Iron & Steel Co., Ltd.
Works at Kamaishi, Japan. (*Sections and bars.*)
Works at Kawasaki, Japan. (*Rolling mills for strips for electric resistance welded tubes.*)
Works at Muroran, Japan. (*Billets, sections and bars.*)

Fukushima Seiko Co., Ltd., Fukushima, Japan. (*Castings.*)

Hakodate Dock Co., Ltd., Hakodate Shipyard, Hakodate, Japan. (*Small castings and forgings.*)

Haneda Pipe Works Co., Ltd., Tokyo, Japan. (*Seamless tubes.*)

Hatakeyama Iron Works Co., Ltd., Komatsugawa.
Works: Tokyo, Japan. (*Small forgings.*)

Hitachi Ltd.
Hitachi Works, Hitachi, Japan. (*Castings.*)
Katsuta Works, Katsutashi, Inaragi-ken. (*Ingots, forgings and castings.*)

Hokuriku Kogyo Co., Ltd., Sanjo Plant, Sanjo, Niigata Prefecture, Japan. (*Small forgings.*)

Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo. Japan. (*Ingots, forgings and castings.*)

Japan Special Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings, blooms, billets and bars.*)

Japan Steel Works Ltd., Muroran Works, Muroran, Japan. (*Ingots, forgings, castings and plates.*)

Jonan Ironworks Co., Ltd., Haneda Works, Tokyo, Japan. (*Small forgings.*)

Kakegawa Endo Iron Works Co., Ltd., Kakegawa, Japan. (*Forgings.*)

Kanto Special Steel Works Ltd., Fujisawa, Kanagawa Pref., Japan. (*Forgings.*)

Kawaguchi Kinzoku Kogyo Kabushiki Kaisha, Kawaguchi, Japan. (*Castings.*)

Kawasaki Steel Corporation, Chiba Works, Chiba, Japan. (*Slabs and plates.*)

Kureha Seitetsu Co., Ltd., Toyama, Japan. (*Ingots.*)

Mitsubishi Nippon Heavy Industries, Ltd., Yokohama Shipyard and Engine Works, Yokohama, Japan. (*Ingots, blooms, small forgings and castings.*)

Mitsubishi Steel Manufacturing Co., Ltd., Tokyo, Japan.
Hirota Works, Fukushima Pref. (*Castings.*)
Tokyo Steel Works, Fukagawa Steel Manufacturing Dept. (*Billets, bars and small forgings.*)
Tokyo Steel Works, Oshima Steel Manufacturing Dept. (*Rolling mills for billets and bars.*)

Nihon Cast Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*)

Niigata Engineering Co., Ltd., Niigata, Japan. (*Castings, ingots and forgings.*)

Nippon Chuzo Kabushiki Kaisha, Kawasaki, Japan. (*Ingots and castings.*)

Yokohama—*continued*

Nippon Kokan Kabushiki Kaisha.

Asano Dockyard, Yokohama, Japan. (*Small forgings.*)

Kawasaki Iron Works, Kawasaki, Japan. (*Tubes, bars and sections.*)

Mizue Ironworks, Kawasaki, Japan. (*Plates up to ½-inch in thickness.*)

Tsurumi Iron Works, Tsurumi, Yokohama, Japan. (*Ingots and plates.*)

Nippon Stainless Steel Co., Ltd., Naoetsu Works, Niigata, Japan. (*Ingots, forgings and castings.*)

Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan. (*Ingots, forgings, bars and sheets.*)

Nisso Steel Manufacturing Co., Ltd.

Naoetsu Factory, Naoetsu, Niigata, Japan. (*Ingots and castings.*)

Oshima Plant, Tokyo, Japan. (*Castings, plates and ingots for forging and plate.*)

Toyama Factory, Toyama City, Japan. (*Ingots and forgings.*)

Nittoku Metal Industry Co., Ltd., Tokyo, Japan. (*Small forgings.*)

Osaka Shipbuilding Co., Ltd., Taira Steel Works, Taira City, Fukushima Prefecture, Japan. (*Castings.*)

Riken Tanzo Co., Ltd., Maebashi Plant, Maebashi, Japan. (*Small forgings.*)

Shimizu Forge Co., Ltd., Tokyo, Japan. (*Forgings.*)

Shin Nippon Tanko K.K., Kawasaki, Japan. (*Small forgings.*)

Sunnan Iron Works Co., Ltd., Yaizu, Japan. (*Forgings.*)

Yokohama—*continued*

Takasaki Metal Industry Co., Ltd., Takasaki Plant, Takasaki, Japan. (*Small castings.*)

Tohoku Special Steel Works Ltd., Sendai, Japan. (*Ingots, small forgings, billets and bars.*)

Tokushu Seiko (Special Steel Mfg.) Co., Ltd., Kawasaki *Works:* Kawasaki, Japan. (*Ingots, forgings and bars.*)

Tokyo Kikai Kabushiki Kaisha, Oshima Cast Steel *Works:* Tokyo, Japan. (*Castings.*)

Tokyo Precision Forging Works Co., Ltd. (Tokyo Seitan Works Co., Ltd.), Ichikawa City, Chiba Prefecture, Japan. (*Small forgings.*)

Tokyo Shibaura Electric Co., Ltd., Turbine Works, Yokohama, Japan. (*Small castings.*)

Tokyo Steel Casting Co., Ltd., Tokyo, Japan. (*Castings.*)

Tokyo Tankosho Co., Ltd., Kawasaki Factory, Kawasaki, Japan. (*Small forgings.*)

Topy Industries, Ltd., Tokyo Works, Tokyo, Japan. (*Sections.*)

Toshiba Steel Co., Ltd., Tokyo, Japan. (*Castings, small forgings, sections and ingots for forging and plates.*)

Uraga Shipbuilding Yard, Uraga Heavy Industries, Ltd., Yokosuka, Japan. (*Castings and small forgings.*)

Watanabe Steel Works Co., Ltd., Tokyo, Japan. (*Castings.*)

Yawata Steel Tube Co., Ltd., Tokyo Japan. (*Rolling mills for weldless rolled or drawn tubes.*)

Yokoyama Engineering Co., Ltd., Tokyo Works, Tokyo, Japan. (*Castings.*)

MANUFACTURERS OF ALUMINIUM ALLOYS

The following establishments have complied with the conditions contained in P 16 to P 18 of the Rules and are recognised by the Committee for the manufacture of aluminium alloys for shipbuilding purposes.

United Kingdom

Alcan Industries Ltd., Banbury. (*Aluminium alloys and products.*)

Alcan Industries Ltd., Newport, Mon. (*Aluminium alloys and products.*)

Almin Ltd.
- International Alloys Ltd., Aylesbury, Bucks. (*Aluminium alloys.*)
- Southern Forge Ltd., Langley, Bucks. (*Aluminium alloy products.*)

Aluminium Wire & Cable Co., Ltd., Port Tennant, Swansea. (*Aluminium alloys and products.*)

Birmetals Ltd., Quinton, Birmingham. (*Aluminium alloys and products.*)

James Booth Aluminium Ltd., Birmingham. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Falkirk. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Redditch Works, Birmingham. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Rheola Works, South Wales. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Bank Quay, Warrington. (*Aluminium alloys and products.*)

High Duty Alloys Ltd., Winscales, Workington. (*Aluminium alloys and products.*)

Imperial Aluminium Co., Ltd., Waunarlwydd, near Swansea. (*Aluminium alloys and products.*)

E. & E. Kaye, Ltd., Enfield, Middlesex. (*Aluminium alloys and products.*)

Austria

Vereinigte Metallwerke Ranshofen-Berndorf A.G., Braunau am Inn. (*Aluminium alloys and products.*)

Belgium

Ateliers Remi Claeys Lichtervelde. (*Aluminium alloy products.*)

Laminoirs de l'Escaut, Burcht. (*Aluminium alloy products.*)

S.A. Sidal, Société de l'Aluminium, Duffel. (*Aluminium alloys and products.*)

Canada

Aluminum Company of Canada, Ltd. (No. 1 Plant), Shawinigan Falls, Quebec. (*Aluminium alloy products.*)

Aluminum Company of Canada, Ltd., Etobicoke Works, Long Branch, Ont. (*Aluminium alloy products.*)

Aluminum Company of Canada, Ltd., Kingston, Ont. (*Aluminium alloys and products.*)

Canada—*continued*

Reynolds Extrusion Co., Ltd.
- Plant No. 1, St. Therese, Quebec. (*Aluminium alloys and products.*)
- Plant No. 4, Oshawa, Ontario. (*Aluminium alloys and products.*)

Finland

Finska Kabelfabriken A/B, Batvik. (*Aluminium alloys and products.*)

France

Aluminium Alcan de France, Luce (Eure & Loire). (*Aluminium alloys and products.*)

Compagnie Générale du Duralumin et du Cuivre (Cegedur).
- Blanc-Mesnil. (*Aluminium alloys and products.*)
- Chambery (Savoie). (*Aluminium alloy products.*)
- Faremoutiers (Seine & Marne). (*Aluminium alloys and products.*)
- Issoire (Puy de Dome). (*Aluminium alloys and products.*)
- Rive de Gier (Loire). (*Aluminium alloy products.*)

Soc. Cuivre et Alliages, Usine a Ham (Somme). (*Aluminium alloys and products.*)

Tréfimétaux, Montreuil-Belfroy. (*Aluminium alloy products.*)

Germany

Aluminiumwalzwerke Singen G.m.b.H., Singen (Hohentwiel). (*Aluminium alloys and products.*)

Otto Fuchs, Meinerzhagen. (*Aluminium alloys and products.*)

Osnabrücker Kupfer - und Drahtwerk, Osnabrück. (*Aluminium alloys and products.*)

Reynolds Aluminiumwerke G.m.b.H., Nachrodt. (*Aluminium alloys and products.*)

Vereinigte Deutsche Metallwerke A.G., Frankfurt-Heddernheim. (*Aluminium alloys and products.*)

Vereinigte Leichtmetall-werke G.m.b.H., Bonn. (*Aluminium alloys and products.*)

Vereinigte Leichtmetall-werke G.m.b.H., Hannover. (*Aluminium alloys and products.*)

Holland

N.V. Nederlandsche Aluminium Maats., Utrecht. (*Aluminium alloys and products.*)

India

Indian Aluminium Co., Ltd., Alwaye, Kerala State. (*Aluminium alloys and products.*)

Indian Aluminium Co., Ltd., Howrah, West Bengal. (*Aluminium alloys and products.*)

Italy

"Delta" Società Metallurgica Ligure S.p.A., Genoa. (*Aluminium alloys and products.*)

Lavorazione Leghe Leggere, Marghera (Venice). (*Aluminium alloys and products.*)

Montecatini Divisione Alluminio e Metalli, Feltre (Belluno) Works, Milan. (*Aluminium alloys and products.*)

Trafilerie e Laminatoi di Metalli S.p.A., Milan. (*Aluminium alloys and products.*)

Japan

Furukawa Aluminum Co., Ltd., Tokyo. (*Aluminium alloys and products.*)

Kobe Steel Ltd., Chofu Plant, Shimonoseki. (*Aluminium alloys and products.*)

Norway

A/S Nordisk Aluminiumindustri, Oslo.
Hoyanger Works. (*Aluminium alloys.*)
Holmestrand Works. (*Aluminium alloy products.*)

Raufoss Ammunisjonsfabrikker, Raufoss. (*Aluminium alloy products.*)

Poland

Bielska Fabryka Wyrobow Srubowych, "Bispol", Bielsko-Biala. (*Aluminium alloy rivets.*)

Walcownie Metali.
Czechowice-Dziedzice Works. (*Aluminium alloy sections, bars and tubes.*)
Kety Works. (*Aluminium alloy, sections and tubes.*)

Spain

Aluminio Earle S.A., Amorebieta. (*Aluminium alloy products.*)

Aluminio Iberico, S.A., Alicante. (*Aluminium alloys and products.*)

Eduardo K. L. Earle, Lejona. (*Aluminium alloys and products.*)

Sweden

A/B Svenska Metallverken, Finspong. (*Aluminium alloys and products.*)

Switzerland

Aluminium Press & Walzwerk A. G., Munchenstein. (*Aluminium alloys and products.*)

Aluminium S.A., Menziken. (*Aluminium alloys and products.*)

Swiss Aluminium Ltd., Chippis. (*Aluminium alloys and products.*)

U.S.A.

Alcan Aluminum Corporation, Oswego, New York. (*Aluminium alloys and products.*)

Yugoslavia

Tvornica Lakih Metala "Boris Kidric", Sibenik. (*Aluminium alloys and products.*)

MANUFACTURERS OF STEEL WIRE ROPE

The following establishments have complied with the conditions contained in P 14 of the Rules and are recognised by the Committee for the manufacture of steel wire ropes.

United Kingdom

Binks Bros. Ltd., London.
British Ropes Ltd., Doncaster.
British Ropes Ltd., Gateshead-on-Tyne.
British Ropes Ltd., Glasgow.
British Ropes Ltd., London.
British Ropes Ltd., Retford.
Bruntons (Musselburgh) Ltd., Musselburgh.
Catherall Ropeworks Ltd., near Sunderland.
Crawhall, Joseph, & Sons Ltd., Gateshead-on-Tyne.
Dawson & Usher Ltd., Sunderland.
Excelsior Ropes Group,
Comprising:—
Excelsior Ropes Ltd.,
Geo. Elliott & Co., Ltd.,
D. Morgan Rees & Sons Ltd.,
Bridgwater-Terrell Ropes Ltd.
Frew Bros. Ltd., Coatbridge.
Glaholm & Robson Ltd., Sunderland.
Glover Bros. (Mossley) Ltd., near Manchester.
The Gourock Ropeworks, Glasgow.
Hall's Barton Ropery Co., Ltd., Hull.
Hood Haggie, R., & Son, Ltd., Newcastle-on-Tyne.
John I. Hopper Ltd., Thornaby-on-Tees.
Latch & Batchelor Ltd., Birmingham.
Martin, Black & Co. (Wire Ropes), Ltd., Coatbridge.
Overton Bros. Wire Ropes Ltd., Hull.
Rylands Bros., Ltd., Warrington.
Scottish Wire Rope Co., Ltd., near Glasgow.
Shaw, John, Ltd., Worksop.
Sheffield Wire Rope Co., Ltd., Sheffield.
Tyne Wire Ropes Ltd., South Shields.
Webster & Co., Ltd., Sunderland.
Whitecross Co., Ltd., Warrington.

Argentina

Establecimientos Metalurgicos Santa Rosa S.A., Buenos Aires.

Australia

Australian Wire Rope Works Pty. Ltd.,Newcastle,N.S.W.

Austria

Felten & Guilleaume Fabrik Elektrischer Kabel, Vienna and Bruck an der Mur.
Joh. Pengg, Draht-und Walzwerke, Thörl bei Aflenz, Steiermark.
St. Egydyer Eisen-und Stahl-Industrie-Gesellschaft, St. Aegyd am Neuwalde.
Teufelberger, K., Drahtseilwerke, Wels, Upper Austria.

Belgium

Anglo-Continental Ropes, Gilly.
"Cabcord" (Société Générale de Cablerie et Corderie), Hamme s/durme.
"Cabcord" (Société Générale de Cablerie et Corderie), Renory.
Cableries & Corderies du Hainaut, S.A., Dour, near Mons.
Cableries & Fonderies de, & à Montignies s/Sambre.
Corderies J. B., Ligny, S.A., des Gilly.
Gonzalez Cock S.A., Lokeren.
Laurent Frères, Boussu-lez-Mons.
Le Lis, S.A., Hamme-sur-Durme.
Van Praet-Dansaert, Baasrode.
Vertongen-Goens S.A., Termonde.

Brazil

Cia. Industrial e Mercantil de Artefatos de Ferros, Sao Paulo.

Canada

Donald Ropes & Wire Cloth Ltd., Hamilton, Ontario.
Greening Wire Rope & Cable Co., Midland, Ontario.
Wire Rope Industries of Canada Ltd. (Canada Wire Ropes Ltd.), Smith Falls, Ontario.
Wire Rope Industries of Canada Ltd., Vancouver, B.C.

Denmark

Jacob Holm & Sønners Fabriker, A/B., Copenhagen.
Randers Rebslaaeri A/S., Randers.

Finland

Oy Teräsköysi, Hämevaara, Nr. Helsinki.

France

Chatillon Tissmétal, Société Anonyme Usines de Sainte-Colombe-sur-Seine (Cote D'or)
Laminoirs-Tréfileries-Cableries de Lens, Lens.
Saint-Frères, S/A, Saint-Ouen, Somme.
Tréfilerie et Cablerie Julien Wurth et Cie., Reichshoffen.
Tréfilerie et Cablerie de Bourg, Usine d'Angers, Angers.
Trefimetaux, Havre.

Germany

Ahlers, C. G., Hanf-u. Drahtseilfabrik, Bremerhaven.
Berkenhoff & Drebes A.G., Asslarer Hutte.
Bertram, J., K.G. Drahtseilwerk, Soest.
Braucke, Adolf vom. A.G., Ihmerterbach.
Bremer Draht-und Seilindustrie G.m.b.H., Bremen-Hemelingen.
Seilindustrie Ernst Deifuss, Unna/Westf.
Dortmunder Drahtseilwerke G.m.b.H., Dortmund.
Drahtseilerei Gustav Kocks, Mülheim (Ruhr)—Broich.
Drahtseilwerke G.m.b.H., Bremerhaven.

Germany—*continued*

Drahtseilwerke Hugo Wohlfahrt, Neheim/Ruhr.
Felten & Guilleaume, Koln-Mulheim.
Gempt, J. H., Lengerich/Westf.
Hamburger Drahtseilerei G.m.b.H., Bad Oldesloe.
Hüttenwerk Oberhausen A.G., Werk Gelsenkirchen vorm. Boecker & Comp.
Klockner - Werke A.G. Dusseldorfer Drahtindustrie, Dusseldorf.
Norddeutsches Drahtseilwerk, A. Brinkmann, Syke.
Seilwerke Heinrich Puth K.G., Blankenstein, Ruhr.
Vornbäumen, J. & W., K.G., Iburg.
Westdeutsche Seilindustrie Paul Stoessel, Osterrath b/Dusseldorf.
Westfälische Drahtindustrie, Hamm.
Westfälische Union A.G., Lippstadt.
Westfälische Union A.G., für Eisen und Drahtindustrie, Drahtseilwerk Oesede.
Wolf, Gustav, Gütersloh.

Holland

Staaldraadkabel & Herculestouwfabriek J. C. den Haan, Gorinchem.
Vereenigde Touwfabrieken, Leiderdorp.

Hong Kong

Hong Kong Steel Ropes Ltd., Kowloon.

India

J. K. Steel Ltd., Calcutta.
National Rolling & Steel Ropes Ltd., Calcutta.
Seshasayee Wire Ropes, Ltd., Alwaye, Kerala.
United Wire Ropes Ltd., Bombay.
Usha Martin Black Wire Ropes Ltd., Ranchi.

Israel

Wire Rope Works Messilot Ltd., Doar Na Gilboa.

Italy

Acciaierie Ferriere Lombarde Falck, Sesto San Giovanni.
Giuseppe & Fratello Redaelli S.p.A.,—Gardone val Trompia (Brescia), Brescia.
Societa Italiana Derivati Vergella, S.p.A. (D.E.R.I.V.E.R.), Sezione di Torre Annuziata.
Industrie Metallurgiche Piemontesi, Susa.
Ing. Guido Scolari (Soc., Acc., Semp.), Milan.
Stabilimenti G. Fornara & Co., Turin.

Japan

Ako Rope & Mfg. Co., Ltd., Sakoshi.
Asahi Wire Rope Manufacturing Co., Ltd., Osaka.
Daido Wire Rope Mfg. Co., Ltd., Osaka.
Igeta Wire Rope Co. Ltd., Izumisano
Kasuga Seiko K.K., Osaka.
Kawasaki Steel Corporation, Chiba Iron and Steel Works, Chiba City.
Kokoku Iron & Steel Wire Mfg. Co., Ltd., Niigata.
Kokoku Iron & Steel Wire Mfg. Co., Ltd., Osaka.

Japan—*continued*

Kokoku Iron & Steel Wire Mfg. Co., Ltd., Tokyo.
Nippon Steel Wire & Wire Rope Co., Ltd., Osaka.
Nishida Wire Rope Mfg. Co., Ltd., Osaka.
Sensyu Seiko Co., Ltd., Kaizuka.
Shinko Wire Co., Ltd., Amagasaki.
Showa Wire Rope Mfg. Co., Ltd., Osaka.
Tatsumi Rope Mfg. Co., Ltd., Osaka.
Teikoku Sangyo Co. Ltd., Osaka.
Tokyo Seiko Kaisha, Kokura.
Tokyo Seiko Kaisha, Osaka.
Tokyo Seiko Kaisha, Tokyo.

Mexico

Cables Mexicanos S.A., Mexico.

Norway

Mandal Stal A/S., Mandal.
Norsk Staaltaugfabrik, Trondheim.
Tonsberg Reperbane A/S., Tonsberg.

Poland

Fabryka Lin i Drutu, Bytom Karb.
Sosnowiecka Fabryka Lin i Drutu, Sosnowiec.

Portugal

Cordoaria Lisbonense, Lisbon.
Quintas and Quintas, Povoa do Varzim.
Rodrigues d'Oliveira, M., Sa & Fos, Ltda., Oporto.

South Africa

African Wire Ropes Ltd.
(Rand Ropes Ltd., Germiston).
(Haggie, Son & Love (1936) Ltd., Cleveland).

Spain

Franco Espanola de Alambres, S.A., Bilbao.
"Nueva Montana Quijano", S.A., Santander.
Trenzas y Cables de Acero S.A., Barcelona.

Sweden

Garphytte Bruks A/B., Garphyttan.
Lesjofors A/B., Lesjofors.
Stallinefabriken, David Ahlquist A/B., Roslags-Nasby.
Svenska Stållinor, A/B., Varberg.
Uddeholms A/B., Blombacka Bruk, Lindfors.

United States of America

The Wire Rope Corporation of America, St. Joseph, Missouri.

Yugoslavia

Novosadska Fabrika Kabela, Novi Sad.
"Otocanka", Zadar.

PROVING ESTABLISHMENTS

The following proving establishments are recognised by the Committee of Lloyd's Register for the testing of anchors and chains while licensed by the Ministry of Transport for that purpose.

Principal Superintendent: MR. H. MURPHY. (*Stationed at Netherton.*)

	Superintendents
NETHERTON (near Dudley)—Lloyd's Proving House	MR. H. MURPHY
LOW WALKER-ON-TYNE—Lloyd's Proving House	MR. R. J. VOGAN
BURNBANK—Lloyd's Proving House	MR. S. BOLTON
CARDIFF—Lloyd's Proving House	MR. T. H. WHITWORTH

The following machines have been recognised by the Committee for the testing of anchors and chain cables except for anchors and chain cables bought or sold in the United Kingdom for use on a British ship which are to be tested at a licensed Proving House in the United Kingdom.

Argentine

Direccion General de Administracion Naval, Buenos Aires, Argentine.

Australia

Falkiner Chains Pty. Ltd., South Brisbane, Queensland (for testing chain cables up to 100 tons).

Austria

Ferdinand Freiherr v. Helldorff & Otto Rothart Kettenwerk Brückl, Brückl, Carinthia.

Steirische Kettenfabriken Pengg-Walenta Kommanditgesellschaft, Werk Hansenhütte, Kapfenberg-Hansenhütte, Styria.

Belgium

Adh. Demanet, Gosselies (for testing chains up to 300 tons).

Béliard, Murdoch & Co., Antwerp (for testing anchors and chain cables up to 100 tons).

Mercantile Marine Engineering & Graving Dock Co., Antwerp.

Usines et Aciéries Allard S.A., Mont-sur-Marchienne (for testing anchors only.)

Canada

Canada Chain & Forge Co., Ltd., Granville Island, Vancouver, B.C.

Dominion Chain Co., Ltd., Stratford, Ontario.

Drummond, McCall & Co., Ltd., Quebec.

Czechoslovakia

Trinecké železárny, Velké rijnové Socialistické revoluce, narodni podnik, Retezárna Mala Morávka. (Trinec Iron Works Great Socialistic October Revolution National Corporation, Chain Works Mala Moravka).

Denmark

Orlogsværftet, Holmen, Copenhagen.

Finland

Fiskars A.B., Loimaa.

Wärtsilä-Koncernen A/B., Dalsbruk Järnverk, Helsingfors (for testing chain cables up to 250 tons).

France

Carlier et Cie., St. Amand-les-Eaux (Nord).

Davaine, Fils et Cie., St. Amand-les-Eaux (Nord) (for testing chain cables up to 132 tons).

Ets. Marit, St. Amand-les-Eaux (Nord).

France—*continued*

Fonderies Meridionales, Marseilles (for testing anchors only).

Forges Nationales de la Chaussade à Guérigny, Nièvre (for testing chain cables up to 300 tons).

Manufacture de Chaines et Ancres de Saint-Amand, Etablissements Sirot-Mestreit and Dorémieux Reunis, Saint-Amand-les-Eaux, Nord.

Paoli, J., & Co., Marseilles.

Société des Forges des Fresnes, Fresnes-sur-Escaut (Nord) (for testing chain cables up to 150 tons).

Veille, A., & Co., Le Havre.

Germany

Blohm & Voss A.G., Hamburg.

Dortmund-Hoerder Hüttenunion A.G., Dortmund Works, Dortmund (for testing anchors only).

Dortmunder Kettenfabrik Bernhard Mester, Wetterstr. 10, Dortmund.

Fröndenberger Kettenfabrik, Heinrich Prünte, Frondenberg-Ruhr (for testing chain cables up to 120 tons).

Hansa Ketten-und Maschinenfabrik Haunschild & Co., Dortmund.

Howaldtswerke A.G., Hamburg.

Joto-Werk Josef Topp, Kettenfabrik, Warmen (Ruhr).

Kettenfabrik Kalthof, August Thiele; and August Thiele G.m.b.H., Fabrik für Ketten und Kettenforderer, Kalthof, near Schwerte-Ruhr.

Kettenwerke Schlieper, Grune, Westphalia.

Mannheimer Ankerfabrik u. Hammerwerk Gdbr. Heuss, Mannheim-Industriehafen (Ruhr).

Theile, J. D., Schwerte-Ruhr.

Holland

Koninklijke Nederlandsche Grofsmederij, Leiden.

N.V. Anker-& Kettingfabriek "Schiedam" (*Managing Director:* P. Th. Verhoeff), Schiedam.

Hong Kong

The Taikoo Dockyard & Engineering Co. of Hong Kong Ltd.

India

The Commissioners for the Port of Calcutta, Calcutta.

Italy

Acciaieria e Ferriera del Caleotto S.p.A., Lecco.

Acciaierie Weissenfels, Catenificio, Fusine di Valromana, Udine (for the testing of small chains only).

Neptunia S.r.L., Genoa.

Japan

Hamanaka Chain Manufacturing Co., Ltd., Himeji.

Japan Mechanical Chain Manufacturing Co., Ltd., Osaka.

Komatsu Manufacturing Co., Ltd., Komatsu.

Komatsu Manufacturing Co., Ltd., Osaka Plant, Hirakata.

Koyo Chain Manufacturing Co., Ltd., Osaka.

Onomichi Anchor Manufacturing Co., Ltd., Onomichi (for testing anchors only).

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka.

Toa Seisa Co., Ltd., Himeji.

Tokyo Chain Works Co., Ltd., Tokyo.

Tokyo Steel Casting Co., Ltd., Tokyo.

Norway

Norsk Kjettingindustri A/S, Mandal.

Poland

Stocznia im. Komuny Paryskiej, Gdynia.

South Africa

McKinnon Chain (South Africa) (Pty.) Ltd., Vereeniging, Transvaal.

Spain

Cadenas y Forjádos, S.A., J. M. Olavarri, Bilbao. *Works:* Lejona, Bilbao.

Don Ciriaco Rodriguez Dorado, Barcelona (for testing chain cables up to 30 tons).

Forjas de San Martin de Pedro Framis, Barcelona (for testing chains up to 16 tons).

Vicinay, S.A., Duesto.

Sweden

Gunnebo Bruks Aktiebolag, Gunnebobuck, Västervik (for testing chains up to 75 tons).

Jarnbirger A/B, Orsa.

Ramnäs Bruks Aktiebolag, Ramnäs.

Statens Provningsanstalt (Government Establishment), Stockholm.

Ström-Ljusne Aktiebolag, Ljusne.

United Kingdom

Brown, Lenox & Co., Ltd., Pontypridd, Monmouthshire.

North British Electric Welding Co., Ltd., Coatbridge, Lanarkshire.

British Tayco Chain Co., Ltd., Brierley Hill, Staffs.

United States

American Chain Co., Braddock, near Pittsburgh, Pa.; and York, Pa. (for testing chains up to 22 tons).

Baldt Anchor Chain & Forge Division of Universal Marion Corp., Chester, Pa.

Baldt Anchor Chain & Forge Division of Universal Marion Corp. Fieldsboro, N.J.

Bellingham Chain & Forge Co., South Bellingham, Wash.

Buckeye Steel Castings Co., Columbus, O. (for breaking tests on chain cables only).

Johnson-Farmer Chain Division of the Boston Metals Co., Lebanon, Pa.

United States—*continued*

McKay Company, McKees Rocks, near Pittsburgh, Pa.

National Erie Co., Erie, Pa. (for testing anchors only).

Pacific Chain & Manufacturing Co., Portland, Or.

Republic Steel Corporation, Round Chain Division.
Broadway & Chaincraft Roads, Cleveland, O.
6921, East Marginal Way, Seattle 8, Wash.

Taylor, S. G., Chain Company, Hammond, Indiana.

Yugoslavia

Tovarna Verig, Lesce pri Bledu.

ELECTRICALLY WELDED STEEL CHAIN CABLES
and
CAST STEEL CHAIN CABLES

The following establishments have complied with the requirements for manufacture of electrically welded and cast steel chain cables and have been recognised by the Committee:—

GRADE U 1 (a) *Flash butt welded chain cables of mild steel having a tensile breaking strength of 19·7 to 26 tons per sq. inch.*

GRADE U 1 (b) *Flash butt welded chain cables of mild steel having a tensile breaking strength of 26 to 31·7 tons per sq. inch.*

GRADE U 2 (a) *Flash butt welded or drop forged special quality steel having a tensile breaking strength of 31·7 to 41·3 tons per sq. inch.*

GRADE U 2 (b) *Cast Steel having a minimum tensile breaking strength of 31·7 tons per sq. inch.*

GRADE U 3 *Flash butt welded or drop forged extra special quality steel having a minimum tensile breaking strength of 44·4 tons per sq. inch.*

NOTE: Before acceptance on classed ships chain cables must be tested on a chain cable testing machine recognised by the Society.

FIRM	GRADE & TRADE NAME (IF ANY)	MAXIMUM DIAMETER	SURVEYING DISTRICT
United Kingdom			
Beal & Son (Cable Makers) Ltd., Cardiff.	U 1 (a), U 1 (b) & U 2 (a)	4 ins.	Cardiff
Bradney Chain & Engineering Co. Ltd., Cradley Heath.	U 2 (a) (Meyer, Roth and Pastor)	$1\frac{3}{8}$ ins.	Birmingham
	U 1 (b) (Short link)	$\frac{1}{2}$ in.	
The British Tayco Chain Co Ltd., Brierley Hill, Staffs.	U 1 (a) & U 1 (b)	$4\frac{1}{8}$ ins.	Birmingham
	U 2 (a) (Tayco)	$4\frac{1}{8}$ ins.	
	U 2 (a) (New Process Tayco)	$3\frac{5}{16}$ ins.	
The British Tayco Chain Co. Ltd., Old Hill, Staffs.	U 1 (a), U 1 (b) & U 2 (a)	2 ins.	Birmingham
Brown, Lenox & Co. Ltd., Pontypridd.	U 1 (a), U 1 (b) & U 2 (a)	4 ins.	Cardiff
	U 2 (b)	3 ins.	
Chain Developments Ltd., (N. Hingley & Co. Ltd.), West Bromwich.	U 1 (a) & U 1 (b)	$1\frac{1}{4}$ ins.	Birmingham
Griffin-Woodhouse Ltd., Cradley Heath, Staffs.	U 2 (a)	$2\frac{3}{16}$ ins.	Birmingham
North British Electric Welding Co. Ltd., Whifflet, Coatbridge, Lanarkshire.	U 1 (a), U 1 (b) & U 2 (a)	$4\frac{1}{8}$ ins.	Glasgow
Parsons Chain Co. Ltd., Stourport-on-Severn.	U 1 (a), U 1 (b) & U 2 (a) (Short link)	$1\frac{1}{4}$ ins.	Birmingham
Wheway Watson Ltd., Govan Works, Glasgow.	U 2 (a) (Short link)	$\frac{7}{8}$ in.	Glasgow
Wheway Watson Ltd., Walsall Works, Walsall.	U 1 (a)	$\frac{7}{8}$ in.	Birmingham
	U 1 (b) (Short link)	$\frac{11}{16}$ in.	

Firm	Grade & Trade Name (if any)	Maximum Diameter	Surveying District
Australia			
Falkiner Chains Pty. Ltd., South Brisbane.	U 1 (a)	$2\frac{5}{16}$ ins.	Brisbane
	U 1 (b) (Short link)	$\frac{3}{4}$ in.	
	U 2 (a) (Famac)	2 ins.	
Austria			
Ferdinand Freiherr v. Helldorff & Otto Rothart Kettenwerk Brückl, Brückl.	U 1 (a) (Short link)	26 mm.	Vienna
Steirische Kettenfabriken Pengg-Walenta Kommanditgesellschaft, Styria.	U 1 (a)	44 mm.	Vienna
	U 1 (b) & U 2 (a)	41 mm.	
Belgium			
Adh-Demanet, Gosselies.	U 1 (a), U 1 (b) & U 2 (a)	76 mm.	Antwerp
Czechoslovakia			
Třinecké Železárny Velke Řijnové Socialistické Revoluce, Národni Podnik, Řetězárna Malá Morávka (Trinec Iron Works Great Socialistic October Revolution National Corporation, Chain Works Malá Morávka).	U 1 (a) & U 1 (b)	46 mm.	Vienna
Finland			
Fiskars A.B., Loimaa.	U 1 (a)	36 mm.	Abo
Oy Wartsilä A.B., Dalsbruk Works, Dalsbruk.	U 1 (a), U 1 (b) & U 2 (a)	64 mm.	Abo
France			
M. Carlier & Cie., St.-Amand-les-Eaux, Nord.	U 1 (a) & U 1 (b)	30 mm.	Valenciennes
Davaine Fils et Cie., St.-Amand-les-Eaux, Nord.	U 1 (a) & U 1 (b)	30 mm.	Valenciennes
Forges Nationales de la Chaussade, Guerigny.	U 2 (a)	80 mm.	Marseilles
Manufacture de Chaines et Ancres de Saint-Amand,	U 1 (a), U 1 (b) & U 2 (a)	100 mm.	Valenciennes
Etablissements Sirot-Mestreit and Dorémieux Reunis. Saint-Amand-les-Eaux, Nord.	U 1 (a), U 1 (b) & U 2 (a)	82 mm.	Valenciennes
Etablissements Marit, Saint-Amand-les-Eaux, Nord.	U 1 (a) & U 1 (b)	44 mm.	Valenciennes
Soc. des Forges de Fresnes, Fresnes sur Escaut, Nord.	U 1 (a) & U 1 (b)	65 mm.	Valenciennes
	U 2 (a)	60 mm.	
A. Veille et Cie., Le Havre.	U 1 (a), U 1 (b) & U 2 (a)	100 mm.	Havre
	U 1 (a), U 1 (b) & U 2 (a) (Monobloc)	91 mm.	

Firm	Grade & Trade Name (if any)	Maximum Diameter	Surveying District
Germany			
Dortmunder Kettenfabrik B. Mester, Dortmund.	U 1 (a) & U 2 (a)	69 mm.	Dortmund
Hansa Ketten-und Maschinenfabrik Haunschild & Co., Dortmund.	U 1 (a)	90 mm.	Dortmund
	U 2 (a)	85 mm.	
Joto-werk, Josef Topp Kettenfabrik, Warman (Ruhr).	U 1 (a) & U 1 (b)	68 mm.	Dortmund
	U 2 (a)	62 mm.	
Kettenfabrik Kalthof, August Thiele; August Thiele G.m.b.H. Fabrik für Ketten und Kettenforderer, Kalthof, near Schwerte-Ruhr.	U 1 (a), U 1 (b) & U 2 (a)	105 mm.	Dortmund
Kettenwerke Schlieper, Grune-Westfalen.	U 1 (a), U 1 (b) & U 2 (a)	110 mm.	Dortmund
Theile, J. D., Schwerte-Ruhr.	U 1 (a), U 1 (b) & U 2 (a)	92 mm.	Dortmund
Holland			
Anker-En Kettingfabriek "Schiedam", Schiedam.	U 2 (a)	78 mm.	Rotterdam
Koninklijke Nederlandsche Grofsmederij, Leiden.	U 1 (a), U 1 (b) & U 2 (a) (Ego)	93·5 mm.	Rotterdam
	U 1 (a) & U 1 (b) (Eldam)	75 mm.	
	U 1 (a), U 1 (b) & U 2 (a)	105 mm.	
Italy			
Acciaieria e Ferreira del Caleotto, Lecco.	U 1 (a), U 1 (b) & U 2 (a)	90 mm.	Milan
Japan			
Hamanaka Chain Manufacturing Co. Ltd., Himeji.	U 1 (a), U 1 (b) & U 2 (a)	150 mm.	Kobe
Japan Mechanical Chain Manufacturing Co. Ltd., Osaka.	U 2 (a) (Kikai)	64 mm.	Kobe
	U 1 (a), U 1 (b) & U 2 (a) (Flash welded)	58 mm.	
Komatsu Manufacturing Co. Ltd.,			
Osaka Plant	U 2 (a)	97 mm.	Kobe
Komatsu Works	U 2 (b)	114 mm.	Kobe
Koyo Chain Mfg. Co. Ltd., Osaka.	U 1 (a), U 1 (b) & U 2 (a)	42 mm.	Kobe
Osaka Chain & Machinery Mfg. Co. Ltd., Osaka.	U 2 (a)	97 mm.	Kobe
	U 2 (b)	89 mm.	
Tokyo Chain Works Co. Ltd., Tokyo.	U 1 (a), U 1 (b) & U 2 (a)	150 mm.	Yokohama
Tokyo Steel Casting, Co. Ltd., Tokyo.	U 2 (b)	150 mm.	Yokohama
Norway			
Norsk Kjettingindustri A/S, Mandal.	U 1 (a) (Short link)	25 mm.	Oslo
	U 1 (a) (Stud link)	32 mm.	
	U 2 (a) (Stud link)	27 mm.	

Firm	Grade & Trade Name (if any)	Maximum Diameter	Surveying District
Poland			
Stocznia im. Komuny Paryskiej, Gdansk.	U 1 (a), U 1 (b) & U 2 (a)	70 mm.	Gdansk
South Africa			
Cotts Steel Industries (Pty) Ltd., Johannesburg.	U 1 (a), U 1 (b) & U 2 (a)	$1\frac{3}{8}$ ins.	Vereeniging
McKinnon Chain (South Africa) (Pty) Ltd., Vereeniging.	U 1 (a) (Short link)	$\frac{3}{4}$ in.	Vereeniging
Spain			
Cadenas y Forjados, Bilbao.	U 1 (a), U 1 (b) & U 2 (a)	85 mm.	Bilbao
Vicinay S.A., Deusto.	U 1 (a), U 1 (b) & U 2 (a)	95 mm.	Bilbao
Sweden			
Gunnebo Bruks Aktiebolag, Gunnebobruk.	U 1 (a) & U 1 (b)	16 mm.	Stockholm
Jarnbirger A/B, Orsa.	U 1 (a), U 1 (b) & U 2 (a)	55 mm.	Stockholm
Ramnäs Bruks Aktiebolag, Ramnäs.	U 1 (a), U 1 (b) & U 2 (a)	98 mm.	Stockholm
Ström-Ljusne Aktiebolag, Kattingfabriken, Ljusne.	U 1 (a), U 1 (b) & U 2 (a)	92 mm.	Stockholm
United States of America			
Baldt Anchor, Chain & Forge Division of Universal Marion Corporation, Chester, Pennsylvania.	U 2 (a) (Weld in alternate links)	$\frac{5}{8}$ in.	Philadelphia
	U 2 (a) (Flash welded)	$4\frac{1}{4}$ ins.	
The Pacific Chain & Manufacturing Co., Oregon.	U 1 (a), U 1 (b) & U 2 (a)	$2\frac{7}{16}$ ins.	Seattle
Yugoslavia			
Tovarna Verig, Lesce.	U 1 (a), U 1 (b) & U 2 (a)	100 mm.	Rijeka

Chapter R

PROVISIONAL RULES AND GUIDANCE NOTES

Explanatory Notes

PROVISIONAL RULES give requirements which have been framed primarily for the initial regulation of ship and machinery applications in process of development ; they are subject to continuous review.

GUIDANCE NOTES are intended as recommendations to designers, based on good practice, in matters for which the present state of knowledge does not justify precise requirements.

R (A)—PROVISIONAL REQUIREMENTS FOR THE USE OF METHANE GAS AS FUEL FOR THE PROPULSION OF METHANE TANKERS

Section 1

General

101 In methane tankers the methane "boil-off" may be used as fuel for propulsion services subject to compliance with the following requirements or equivalents; it is not to be used for firing donkey or domestic boilers or for auxiliary engine services.

102 These provisional requirements are based on the assumption that the pressure of the gas supply to the machinery space will not exceed 15lb. per square inch (1 kg. per cm.2) gauge for boilers, and 100lb. per square inch (7 kg. per cm.2) gauge for oil engines, and that the gas temperature in both cases will be approximately ambient. Where higher pressure or temperature conditions are proposed the arrangements will be specially considered.

It is also assumed that adequate oil fuel bunkers will always be carried and that the ship will not be entirely dependent on the methane "boil-off" for fuel requirements during any voyage.

Plans

103 The following plans are to be submitted for consideration:—

General arrangement of plant.

Gas piping system, together with details of interlocking and safety devices.

Gas heaters.

Gas compressors and their prime movers.

Gas storage pressure vessels.

Gas and oil fuel burning arrangements.

Equipment for Heating, Compressing and Storing Methane Gas

104 The methane gas is to be heated and compressed outside the machinery space. If the gas is stored in a pressure vessel the latter is also to be located outside the machinery space.

105 Gas heaters and compressors, of watertight construction, may be installed on the open deck provided they are suitably located and protected from mechanical damage. Alternatively, the heaters and compressors may be installed in a well ventilated compartment outside the machinery space. This compartment is to be treated as a dangerous space to which the requirements of M 16 for electrical equipment are applicable.

106 If steam is adopted as the heating medium the steam supply to the heaters is to be automatically controlled by the discharge temperature of the methane from the heaters, and the steam drains are to be led to a vented drain tank outside the machinery space. The vents are to be led to a safe position.

107 The prime movers for the gas compressors are to be regulated to maintain a positive suction pressure and arranged to stop automatically if the pressure on the suction side of the compressors is lower than ½lb. per square inch gauge (0,035 kg. per cm.2) or other approved positive pressure appropriate to the cargo tank system. They are also to be capable of being stopped, in emergency, from suitable positions on deck and in the machinery space.

108 Gas compressors of the piston type are to be fitted with relief valves discharging to a safe position. The relief valves are to be so proportioned and adjusted that the accumulation with the outlet valves closed will not exceed 10 per cent of the maximum working pressure.

109 The suction and discharge connections to the compressors are to be fitted with isolating valves and flame arresters.

110 Pressure vessels for storing methane gas are to be of approved design and fitted with pressure relief valves discharging to atmosphere in a safe position.

Ventilation of Machinery Spaces

111 Efficient arrangements are to be provided for the thorough ventilation of the machinery space under all climatic conditions and are to include a monitoring system with visual and audible warnings to detect gas leaks.

Gas Supply Pipes in Machinery Spaces

112 The gas supply lines in the machinery space are to be fitted in trunks or casings which are maintained by exhaust fans at a pressure slightly below that prevailing in the machinery space. The fans are to be of a type in which the electric motor is outside the ducting. The air discharge is to be led to a safe position and is to be monitored for methane leakage. Alternatively, the supply lines may be contained in trunks or casings pressurised by an inert gas at a pressure appreciably higher than the methane gas pressure. The gas supply lines are to be located remote from the ship's sides. Indicators of the trunk ventilation or pressurisation are to be provided.

113 The gas supply lines in the machinery space are to have all-welded joints so far as practicable, and are to be tested in place by hydraulic pressure to 100lb. per square inch (7 kg. per cm.^{2}) or twice the working pressure, whichever is the greater. Subsequently, the lines are to be tested by air at the working pressure using "Soapy Water", or equivalent, to verify that all joints are absolutely tight.

114 Provision is to be made at a suitable position on deck for shutting off the gas supply before it enters the machinery space.

Purging Arrangements

115 Arrangements are to be made for purging the complete methane system with an inert gas or steam before and after pipes, auxiliaries, etc., are opened up for inspection or overhaul.

Electrical Equipment

116 The location of electrical equipment, including switchboard, is to be such that an accumulation of gas in the vicinity of such equipment is not possible.

MAIN BOILERS

Requirements for Burning Methane Gas

117 The boilers are to be equipped for oil firing in addition to the gas firing. Oil fuel alone is to be used for starting-up, port operations and manœuvring.

118 The boiler room is to be separated from the engine room by a bulkhead, roller fire screen or equivalent. Each boiler is to have a separate uptake to the top of the funnel or a separate funnel.

119 The draught arrangements are to be such that a pressure differential is maintained between the boiler room and the combustion chamber either by induced draught fans or by a closed stokehold system of forced draught. Alternatively, the boilers may be enclosed in a pressurised air casing.

120 The gas manifolds together with control valves are to be contained in a casing which is maintained below engine room pressure by an exhaust fan discharging to a safe position. Alternatively, the gas manifolds, valves, etc., may be contained in casings pressurised by inert gas as described in 112.

121 The firing equipment is to be of combined gas and oil type and be capable of burning both fuels simultaneously. The gas nozzles are to be so disposed as to obtain ignition from the oil flame which is to be present under all conditions of firing. A mechanical inter-locking device is to be provided to prevent the gas supply being opened until the oil and air controls are in the firing position. Each burner supply pipe is to be fitted with a gas shut-off cock and a flame arrester unless the latter is incorporated in the burner. An audible alarm is to be provided giving warning of loss of minimum effective pressure in the oil fuel discharge line or failure of the fuel pump.

122 Arrangements are to be made so that the gas supply to the gas manifold at each boiler can be shut off manually at the firing platform and will be shut off automatically as a result of failure of the forced draught fans or too low a pressure in the gas supply line.

123 An inert gas or steam purging connection is to be provided on the burner side of the shut off arrangements required by 122 so that the pipes to the gas nozzles can be purged immediately before and after methane gas is used for firing purposes.

124 A notice board is to be provided at the firing platform stating:—

> If ignition is lost from both oil and gas burners, the combustion spaces are to be thoroughly purged of all combustible gases before re-lighting the oil burners.

MAIN OIL ENGINES

Requirements for Using Methane Gas

125 Main engines are to be of the dual fuel type employing pilot oil fuel ignition and capable of immediate change-over to oil fuel only. All starting and manœuvring is to be carried out on oil fuel alone.

126 The gas is to be admitted to each cylinder via a separate gas inlet valve; i.e. a system whereby gas is supplied to and mixed with air in a common inlet manifold is not acceptable from safety considerations. The gas supply pipes to individual cylinders are to be fitted with shut-off valves, non-return valves and flame arresters.

127 Isolating valves are to be provided at the inlet to the gas supply manifold for the engine and are to be arranged to close automatically in the event of low gas pressure and failure of pilot fuel injection. Arrangements are to be made so that the gas supply to the engine can be shut off manually from the starting platform.

128 Explosion relief valves are to be provided in the exhaust, scavenge and air inlet manifolds for conditions where, for example, a cylinder misfires due to failure of the pilot fuel injection or other derangement.

129 A cowl or casing connected to an exhaust ventilator is to be fitted over the cylinder tops so that gas leakages may be intercepted and led to a safe position. No electrical equipment is to be fitted inside these cowls and casings.

130 If a trunk piston engine is used the crankcase is to be fitted with smoke detecting equipment and means for the automatic injection of inert gas to avoid the special hazard of an explosion in a crank case which normally will contain a methane/air mixture. Crank case relief valves are also to be fitted as required by H 7.

Survey

131 The gas compressors, heaters, pressure vessels and piping are to be constructed under Special Survey, and the installation of the whole plant on board the ship is to be carried out under the supervision of the Society's Surveyors.

28th February, 1963

R (B)—PROVISIONAL REQUIREMENTS FOR PLASTIC PIPES

Section 1

101 Proposals to use plastic type materials in shipboard piping systems will be considered in relation to the properties of the materials, the operating conditions of temperature and pressure, and the intended service.

The requirements which follow are intended for extruded plastic pipes; they may also be used, where applicable, for fabricated plastic pipes glass reinforced. Any proposed service for plastic pipes not mentioned in these requirements is to be submitted for special consideration.

102 A specification of the plastic material giving mechanical and thermal properties is to be submitted for consideration.

103 In general, plastic pipes are not to be used where they will be subjected to temperatures above 120° F. (49° C.) or below 32° F. (0° C.).

104 Plastic pipes of approved type may be used for the following services:—

(*a*) Air and sounding pipes to tanks used exclusively for carrying water ballast or fresh water, with the exception of the portion above deck.

(*b*) Sounding pipes to cargo holds.

(*c*) Water ballast and fresh water pipes situated inside tanks used exclusively for carrying water ballast or fresh water.

(*d*) Scupper pipes draining inboard provided they are not led within the boundaries of refrigerated chambers.

Items (*a*) and (*b*) are not applicable to passenger ships.

105 Plastic pipes may be used for domestic and similar services for which there are no rule requirements, as follows:—

Domestic cold salt and fresh water systems.

Sanitary salt water systems.

Sanitary and domestic waste pipes wholly situated above the freeboard deck.

Water pipes associated with air conditioning plants.

106 Since plastic materials are generally heat sensitive and very susceptible to fire damage, plastic pipes will not be acceptable for services essential to safety, as follows:—

Fire extinguishing pipes.

Bilge pipes in cargo holds.

Bilge and ballast pipes in the machinery space.

Main and auxiliary water circulating pipes.

Feed and condensate pipes.

Pipes carrying oil or other inflammable liquids.

107 If plastic pipes are arranged to pass through watertight or fire-resisting bulkheads or decks provision is to be made for maintaining the integrity of the bulkhead or deck in the event of pipe failure. Details of the arrangements are to be submitted for approval.

108 Pipes are to be of robust construction, and in general so designed that the wall stress will not exceed $\frac{1}{7}$ of the tensile strength of the material at the working temperature. Particulars of scantlings and joints are to be submitted for consideration.

109 All pipes are to be adequately but freely supported; suitable provision for expansion and contraction is to be made in each range of pipes to allow for large movements between plastic pipe and steel structure—the coefficient of thermal expansion for plastics being eight or more times that of steel.

110 All fittings and branches are to be suitable for the intended service having joints of cemented, flanged, or other approved type.

111 The strength of the plastic material is to be check tested at the Surveyor's discretion. The tensile strength is to be determined by pressure tests to destruction on sample pipes. The pressure is to be so applied that failure of the pipe occurs in not less than five minutes. Bulging of the pipe during test is acceptable. The tensile strength is to be taken as the hoop stress at failure based on the original pipe dimensions.

28th February, 1963

R (C)—PROVISIONAL RULES FOR NUCLEAR SHIPS

Section 1

GENERAL

101 The class notation "Nuclear Powered" will be assigned, in accordance with the provisions of Chapter B, to sea-going ships equipped with a nuclear reactor or reactors for main propulsion and built in accordance with, or equivalent to, the relevant Rules and the following special requirements.

102 The requirements of Chapters C to P apply as may be relevant to nuclear-powered ships, except as otherwise required by the following rules.

HULL

Definitions

103 The containment structure is the vessel or ship compartment containing the reactor, primary circuit and associated equipment.

104 The containment protection length is the overall length of the containment structure plus a marginal length at each end. The marginal length is to be not less than B/5 with a minimum of 10 feet (3 metres).

105 The reactor compartment is that compartment of the ship containing the containment structure. Where the containment structure is integral with the hull the reactor compartment is the containment structure (*see* 103).

Method of Construction

106 Welded construction is to be adopted for all structural material bounding the containment structure.

Quality of Material

107 The material of deck, sheerstrake, side and bottom shell plating, including keel, over the containment protection length is to be of Grade E.

Longitudinal Strength

108 Curves of weight and buoyancy in still water, and the corresponding bending moments and shear forces are to be submitted. The minimum section modulus for the hull shall be in accordance with the requirements of the Rules. In general, the arrangements and loading should be so adjusted that the maximum stress in still water does not exceed 90% of the normal rule maximum.

109 The longitudinal extent of the midship thicknesses of the deck, sheerstrake, side and bottom shell plating will be considered in association with the bending moment and shear force diagrams, but is to be not less than required by the appropriate section of the relevant Rules.

110 Continuity of longitudinal strength members is to be provided and rapid changes of section are to be avoided. The containment protection may be tapered to the normal structure over the marginal length.

111 Rigid shielding must not encase hull structural members unless built up in units with overlapping or socketed joints to permit free deflection of the ship girder. Thick steel or sandwich structures should not be made an integral part of the hull structure for similar reasons.

External Shock

112 The support system for the reactor and associated components should be designed to withstand a shock or impact acceleration of 3 g in any direction without general deformation of the structure.

Collision and Grounding Protection

113 No part of the containment is to extend outside a vertical datum B/5 feet (metres) inboard of the ship's side at the load water line.

114 The structure of the ship below the reactor and at the sides in way of the containment protection length will require to be specially considered from the aspect of absorption of the energy of collision and grounding forces.

115 Details of the side shell framing and collision protection structure in way of the containment protection length are to be submitted for approval.

116 A double bottom structure of depth not less than 6 feet (1,85 metres) is to be fitted in way of the reactor and should incorporate a system of longitudinal framing in association with bottom transverses.

117 The integration of the containment with the hull structure should be such that the bottom shell in way of

the reactor should be capable of sustaining comparatively severe local damage without prejudicing the support of the reactor and its relative position in the ship.

118 A watertight longitudinal bulkhead is to be fitted between the reactor and the ship's side, not less than 5 feet (1,5 metres) from the inner line of primary shell supporting members (or inner skin if double skin construction is adopted) at the load water line. The minimum clearance between this bulkhead and the reactor installation will be considered in association with the form of collision protection adopted. This bulkhead should, wherever possible, be in line with similar longitudinal material in the half length amidships. Where this is not possible, the arrangements for continuity are to be specially approved.

119 Proposals for the carriage of liquids, or siting of auxiliary machinery, abreast the reactor installation will be the subject of special approval.

Cargo Hazard Protection

120 Cargo spaces are to be isolated from the reactor compartment by a cofferdam not less than 5 feet (1,5 metres) in length. For this purpose the machinery spaces and pump rooms will be regarded as equivalent to cofferdams. The modulus of the stiffening members of the cofferdam bulkhead adjacent to the reactor compartment is to be twice that required by D 50.

Containment Structure

121 Where containment is provided by a pressure vessel independent of the ship's structure, 216 to 225 apply.

122 The arrangements of such a containment structure are to be such that the transmission of stresses from the hull structure is reduced to a minimum.

123 Where the maximum major accident pressure (*see* 501) does not exceed 30 p.s.i. (2 kg. per cm.^{2}) gauge the containment may be provided by a compartment of the hull structure. All material of such containment structures is to have impact properties as specified for Grade E. Details of the proposed material are to be submitted.

124 The design stress for hull containment structures must not exceed two thirds of the yield stress or one third of the ultimate stress under the major accident conditions (*see* 501). Temperature effects will be specially considered. The structure should also be capable of withstanding an external pressure of 50 p.s.i. (3,5 kg. per cm.^{2}) gauge.

125 Containment structures are to be tested on completion in accordance with 224 and 225.

Section 2

PRESSURE VESSELS AND COMPONENTS

201 Pressure vessels and components for nuclear installations are to be considered in the following categories:—

Category "A"

Pressure vessels and components which are:—

1. Intended to contain radioactive materials in service,

and

2. Either (i) subject to direct neutron irradiation such that the physical properties of the materials of construction will be significantly affected during the projected life of the nuclear installation, or (ii) inaccessible for normal comprehensive periodic examination and maintenance from biological considerations of radioactivity.

Category "B"

Pressure vessels and components which are:—

1. Intended to contain radioactive materials in service,

and

2. May be subject to direct neutron irradiation but not such that the physical properties of the materials of construction will be significantly affected during the projected life of the nuclear installation, but which will be accessible for normal comprehensive examination and maintenance at any selected time during the projected life of the nuclear installation.

Category "C"

Pressure vessels and components which are:—

1. Not intended to contain radioactive materials in service.
2. May be subject to direct neutron irradiation but not such that the physical properties of the materials of construction will be significantly affected during the projected life of the nuclear installation and which will be accessible for normal comprehensive examination and maintenance at any selected time during the projected life of the nuclear installation.

Containment

Containment structures are defined in 103.

Category "A"

202 The materials of construction of these vessels are to be of a readily weldable quality, of adequate corrosion resistance and chosen from types which have been proven in pressure vessel service under similar conditions for non-nuclear applications. Data relating to the probable behaviour of materials under irradiation should be available.

203 Irradiation monitoring specimens representative of the materials of construction and of the welding of the vessels are to be provided. A programme of monitor specimen testing is to be drawn up covering the projected life of the nuclear installation.

204 Pressure vessels are to be designed and constructed generally in accordance with the Rules for Welded Pressure Vessels, Class 1. Alternatively, they may be designed generally in accordance with B.S.S. 1500 Class 1 or an approved code of a recognised National Authority.

The design conditions to be adopted are as follows:—

Design pressure is to be the maximum pressure under normal continuous and transient operation. Additionally, the relief valves must ensure that under emergency conditions the accumulation pressure must not exceed 1·10 × design pressure.

Design temperature to be the maximum coolant temperature under normal operating conditions.

205 The effect of the following factors on stress levels must also be taken into consideration:—

(a) (i) Internal and external loading applied by or through circuits, supports and other connections, and self weight.

(ii) Temperature differentials and gradients occurring during normal operation, including start-up and shut-down.

(b) Shock and impact loading (*see* 112 and 521).

206 Special attention is to be given to effecting a clean design minimising stress concentrations. Reinforcement of major nozzle and other openings in the main pressure shell by the use of doubling plates is not permitted. Weldments are to be designed to permit 100 per cent radiography wherever possible.

207 The weld procedure specification is to be prepared giving details of the proposed methods of fabrication, including all pertinent welding variables and proposed methods of non-destructive examination. The specification must also include proposals in respect of the following:—

(a) Weld procedure tests to prove the proposed methods.

(b) Welding operator tests to prove each welder's ability.

(c) Production tests to prove the maintenance during fabrication of the standard of welding established and approved under weld procedure tests. Such tests are to be representative of the final conditions of the welding of the completed vessels and components.

The above tests are to be carried out under the conditions obtaining during fabrication.

208 On completion of fabrication, a hydraulic test is to be applied to a pressure 50 per cent in excess of the design pressure corrected for any increase in thickness incorporated as a corrosion allowance and for any difference in the physical properties of the vessel materials between test and design temperatures.

Category "B"

209 The requirements for vessels in this category are as for Category "A", except that irradiation data on materials is not required.

Internal and external access for normal comprehensive periodic examination of all vessels and components which are accessible from biological considerations of radioactivity is to be provided.

210 The pressure tightness of fuel assembly containers and associated coolant systems should also be considered in this category. Where closure of the pressure shell is effected by mechanical means, facilities are to be provided to test the integrity of the joint against leakage at any selected time.

Categories "A" and "B"

211 Vessels and components of the primary circuit are to be shop fabricated and shop tested wherever possible. The number of *in situ* closing welds must be kept to a minimum and adequate access is to be provided in each case.

212 On completion of the installation of the primary circuit a test pressure of $1\frac{1}{2} \times$ Design Pressure is to be applied.

A leak test is also to be applied to the completed primary circuit for each proposed installation in a manner approved by the Society.

213 Provisions are to be made to facilitate periodic pressure and leak testing of the primary circuit.

214 Construction of these vessels is to be carried out in such a way that the high standard of cleanliness required can be attained.

Category "C"

215 Vessels in this category are to be designed, constructed and tested in accordance with the Rules for Welded Pressure Vessels (Chapter J) or other approved code or specification.

Containment

216 Materials for the construction of these structures are to be of a readily weldable quality and chosen from types which have been proven in service.

217 Where part of the ship structure is used as containment, 123 to 125 in Section 1 are applicable.

218 Pressure vessels are to be designed and constructed generally in accordance with the Rules for Welded Pressure Vessels, Class 1. Alternatively, they may be designed in accordance with B.S.S. 1500 Class 1 or an approved code of a recognised international authority. The allowable design stress must not exceed the lesser of the following:—

Two thirds of yield stress (or two thirds of the 0·2 per cent proof stress),

One third of ultimate tensile stress.

219 No means of internal pressure relief are to be fitted. The design conditions to be adopted are as follows:—

Design pressure (internal) is normally to be the major accident pressure in p.s.i. (kg. per cm.^{2}) gauge. (*see* 501).

Collapse pressure (external) is to be not less than 50 p.s.i. (3,5 kg. per cm.^{2}). Arrangements to protect the vessel when subjected to pressure in excess of the collapse pressure should be submitted for approval.

Temperature effects are to be considered (*see* 502).

220 The following factors are also to be taken into consideration:—

(a) Internal and external loading applied from ship's motion, machinery installation and shielding.

(b) Shock and impact loading (*see* 112 and 521).

221 Where it is envisaged that items of equipment within the containment will be removed or replaced during the life of the installation, adequate shipping openings with mechanical closures are to be provided to avoid recourse to cutting the containment structure in service.

222 The number and size of all openings in the pressure shell is to be kept to a minimum.

Isolating valves must be provided for all pipe circuits penetrating the pressure shell and these are to be situated in accessible locations outside, and adjacent to it. These valves are to be power operated or otherwise arranged to ensure rapid closure when containment is invoked.

223 A weld procedure specification is to be provided.

224 On completion of fabrication an internal hydraulic test to a pressure of at least 25 per cent in excess of the design pressure is to be applied.

225 A leak test to enable the determination of leakage rates from the containment structure at design pressure is to be conducted. Leakage from the containment structure should be kept to a practical minimum. The target figure to be adopted is 1 per cent in 24 hours of the free volume of the gaseous content in the containment vessel with all machinery installed.

Pressure Control and Over-pressure Relief

226 For each pressure vessel in the primary and secondary circuits in which it is possible under any foreseeable conditions for the pressure to rise above the maximum design pressure, over-pressure relief must be possible.

227 The design requirements for primary and secondary pressure control systems are to include an agreed failure of the primary secondary boundary. The effect of the consequent transfer of fluid from the primary to the secondary circuit or from the secondary to the primary circuit is to be assessed.

Discharge from primary pressure circuits is to be contained (*see* 513).

228 In systems where it is practicable to provide total relief capacity during any emergency condition by fitting one safety valve only, an additional safety valve of equivalent capacity is to be fitted. In multi-valve systems, additional safety valves are to be fitted in excess of the number required to provide total relief capacity. The number of additional valves to be provided will depend on the operational reliability of the safety valve types and the number involved.

Relief systems are to be designed to provide total relief capacity during any emergency condition with the maximum pressure accumulation of 10 per cent of the design pressure with the additional safety valves isolated.

229 Provision is to be made to detect leakage from each safety valve in normal operation. Provision is to be made to effect isolation of each safety valve during reactor and circuit operation. The shut-off arrangements are to be interlocked to ensure that the number of valves required to effect total relief are on line.

230 A pressure connection is to be provided to enable testing of safety valve lift *in situ*.

If block valves are proposed in safety valve discharge lines, a low pressure bursting disc must be incorporated in the valve design.

231 Proposed departures from the above requirements will be given special consideration.

Section 3

REACTOR ENGINEERING

General Requirements

301 Normal reactor and main machinery control during power operation are to be effected from a central control position external to the reactor compartment. An emergency reactor shut-down position with monitoring instrumentation is to be provided remote from the central control position.

302 Where isolation of the primary flow between reactor and heat exchanger is not provided, means of individual remote isolation of the secondary side of the heat exchangers is to be provided adjacent to the heat exchangers.

303 Individual isolation of the primary coolant subsidiary circuits is to be provided.

304 Data on the expected degree of irradiation effect to moderator and coolant is to be provided and the proposed method of monitoring and controlling such effect throughout ship life is to be stated.

305 Materials of construction which come into contact with primary fluid should be examined in relation to the build up of corrosion products activity within the reactor system. Details of proposed coolant treatment facilities are to be supplied.

306 Data and, if possible, experimental evidence relating to the power stability of the reactor under regular cyclic motions up to accelerations of ·45 g as may be obtained in a seaway are to be provided. As a design criterion a period of 12 seconds should be used regardless of size and type of ship or position of reactor.

307 Special consideration is to be given to the fire resistance of all materials used in the containment structure and reactor compartment having regard to normal operating conditions and defuelling. Fire protection facilities provided in the containment structure and the reactor compartment are to be submitted for approval.

308 The provision and location of all spare equipment for nuclear components is to be detailed.

309 At least two independent means of charging coolant into the primary system are to be provided.

Reactor Core

310 A specification of all materials proposed for use in the core structure is to be submitted for approval.

311 The data and calculations utilised in the core design are to be submitted for approval.

Where necessary, adequate safeguards must be provided to prevent any dangerous chemical reaction between reactor materials and air or water.

312 The mechanical design, dimensional integrity and manufacturing tolerances of the core structure are to be submitted for examination and approval. Where applicable, the possible relative movement between neutron absorber control material and the core is to be assessed.

313 All possible normal and abnormal reactor transients are to be evaluated and their effect upon the dimensional stability and strength of the reactor core support structure is to be assessed.

314 It is recommended that all reactor pressure vessel internals are to be capable of being dismantled and removed from the pressure vessel. Proposals are to be submitted for consideration.

315 The core structure and fuel assembly are to be capable of withstanding shock and impact loading (*see* 112 and 521).

316 The expected change of the physical and chemical properties of the materials proposed for use in the fuel assembly, with irradiation, are to be submitted for approval.

317 The design of the fuel assembly and the operating criteria upon which the design is based are to be submitted for examination. All possible transient conditions (*see* 313) must be examined and related to possible fuel element failure. Experimental evidence of the mechanical strength of the fuel assembly resulting from transient conditions should be provided where possible.

318 The concentration and composition of fission products in the fuel at the end of the designed core life are to be assessed assuming a final period of 100 hours full-power operation.

319 The evidence upon which the fuel element dimensional stability has been assessed including, where possible,

previous reactor experience with the proposed fuel assembly up to the full proposed design irradiation is to be submitted for examination.

320 The consequences of salt water contamination of the primary coolant and the corrosion rates of the fuel assembly materials in coolant and in sea water are to be determined.

321 An analysis of the consequences of complete loss of coolant flow with and without control action is to be provided.

322 An analysis of the consequences of staggered loss of coolant flow with and without control action is to be provided.

323 An analysis of possible events leading to and resulting from the sudden introduction of cold coolant into the reactor core is to be provided.

324 The influence of random variations in moderator composition is to be examined.

325 An analysis of the consequences of a restriction of coolant flow in a fuel assembly is to be provided.

326 Each main coolant circuit must be provided with an independent means of circulating coolant. A single loop reactor system must be provided with a minimum of two main coolant circulators. It is recommended that a spare pump unit be carried.

327 Alternatively, if natural convection is proposed as a sole means for primary coolant circulation, proposals are to be submitted for consideration.

328 An analysis of the consequences of leakage of primary coolant and associated loss of pressure with and without control action is to be provided.

Decay Heat Removal

329 The arrangements to remove decay heat from the core under normal shut-down conditions are to be submitted for approval. Data, together with method of calculation, is to be provided showing the assessment of variation of decay heat with time.

330 Where a single loop circuit is proposed, a decay heat removal system independent of the main coolant loop is to be provided.

331 Facilities, independent of normal electrical power supplies, are to be provided to remove decay heat from the core at angles of list up to 50°.

It should be assumed that the ship lists to 20° instantaneously and that the list continues to increase at the rate of 20° per hour.

Section 4

REACTOR CONTROL

General Requirements

401 The proposed procedures for start-up and normal and emergency plant operation are to be submitted for approval.

402 The design of the control arrangements and any associated mechanism and the power supply to such mechanisms are to be submitted for approval. Evidence of operational reliability and proposed cycling tests to prove reliability are to be indicated.

403 The physical and chemical properties of materials used in control rod and associated mechanisms are to be submitted for approval. Corrosion rates of control equipment in reactor environment and in sea water are to be determined.

404 The control arrangements are not to move out of the core under gravity, under the force of coolant flow, shock loads or ship movement.

405 A degree of operator adjustment of the control arrangements is to be possible. Protection against possible operator error is to be provided.

406 The normal full-power operating temperatures of control rods are to be determined and the maximum temperature obtaining with one rod stuck in the core is to be determined, together with consequential effects.

407 The maximum insertion and withdrawal rate of any form of control is to be stated and related to possible reactor instability.

408 The consequences of continuous control rod withdrawal at start-up and full power are to be calculated.

409 The control equipment and its associated mechanisms when supported in their environment are to be capable of withstanding shock and impact loading (*see* 112 and 521).

410 The control arrangements are to be capable of operation at all ship angles and in the event of power failure must fail safe.

411 A margin of control should be completely withdrawn prior to criticality. The reduction of reactivity effected due to insertion of this margin at full power, at start-up and at all stages of core lifetime should be stated.

412 An alternative method of shutting down the reactor which is not affected by structural distortion of the core is to be provided, e.g. dumping of the moderator or change in moderator mixture or added poison. The time required to operate the system is to be stated.

Calculations or experiments supporting the design of the chosen system should be submitted for appraisal.

413 The plant parameters and the analysis of transient conditions under which emergency shut-down will be initiated are to be submitted for appraisal.

414 Emergency shut-down of the reactor must be implemented at the following ship conditions:—

(i) 50° list.

(ii) Flooding of the containment.

415 The method proposed to pressurise the primary circuit is to be submitted for approval.

Instrumentation

416 Control instrumentation and supplies are to be defined so as to meet control requirements and fault conditions. The instrument response to reactor transients is to be demonstrated.

417 All nuclear instrumentation, including health physics monitoring equipment, is to be described and its accuracy, reliability and range of operation demonstrated.

418 The method and extent of duplication of essential nuclear instrumentation and supplies is to be stated.

It is required that failure of any item of equipment in any channel shall result in a non-safe indication from that channel. Provision to test each channel without loss of reactor protection is to be possible.

419 All instrumentation relating to the reactor and the reactor compartment is to be described and the range of operation demonstrated.

420 Basic reactor safety instrumentation at the central control position and at the emergency shut-down position must be adequately shock mounted to ensure accuracy and reliability (*see* 112 and 521).

Section 5

COMPLEMENTARY INSTALLATION REQUIREMENTS

Major Accident

501 A containment vessel or structure is required that encloses all primary coolant circuits and the design of this is to be related to a pressure resulting from a major accident. This accident should be based on an appreciation of the particular reactor design and is to include:—

(a) Examination of possible nuclear transients contributing to the energy content of the primary circuit.

(b) Assumption of complete severance of a main coolant pipe or equivalent failure occurring at working pressure and resulting in discharge of primary coolant into the containment.

(c) Assumption that failure of the secondary circuit discharges a proportion of the secondary fluid into the containment.

(d) Consequent exothermic chemical reaction which might result from core melt-down.

502 A pressure/time curve and temperature/time curve of the containment vessel contents covering the first 24 hours after the accident are to be submitted for examination, together with relevant calculations. In addition, the provision to prevent molten fuel penetrating the containment is to be indicated. Where "vapour suppression" or other such means of attenuation of the pressure rise following an accident are proposed full details are to be submitted at an early stage in the design, together with evidence of their effectiveness.

503 An assessment is to be made of possible damage to the containment structure by missiles produced as a consequence of a component failure inside the containment.

504 A summary of credible accidents covering each particular installation and indicating the degree of hazard involved is to be submitted for consideration. This summary must include a schedule of containment penetrations detailing methods of closure.

Shielding

505 Radiation contours in and around the hull, together with method of determination, are to be submitted for approval. Such contours should be determined for full-power operation, shut-down, dry docking, defuelling and after the major accident which invokes the use of containment.

506 In general, designers should work to the recommendations of the International Commission of Radiological Protection so that crews do not receive an integrated radiation dose in excess of 5 rem per year. When the integrated dose is calculated the possible need for maintenance work in high irradiation areas must be considered and it is recommended that 40 per cent of the total dose be reserved for this purpose.

507 The design of primary and secondary shielding, together with their siting and method of securing in the hull structure, are to be submitted for approval. Where necessary, arrangements for shield cooling and ventilation are to be indicated. Adequate periodic examination of the parent structure must be possible.

Defuelling and Refuelling

508 The arrangements for reactor shut-down for maintenance purposes and immediately prior to defuelling are to be submitted for approval.

509 Removal of a fuel assembly from the core into a container is to take place in such a manner that there will be no hazardous release of fission products to environment. The reactor core is to be in a containment of agreed design at all times. In addition, irradiation hazards to personnel are to be limited and should not exceed the maximum dose rates as recommended by the International Commission of Radiological Protection.

510 The fuel container is to be capable of being cooled and the consequences of failure of cooling are to be examined. The method of cooling and any related design of coolant circuit are to be submitted for approval.

511 The design of fuel containers is to be related to an approved maximum pressure and temperature to which they may be subjected, and the leak rate of the containers under such conditions is not to exceed 0·1 per cent per 24 hours of the gaseous volume of the container loaded with a fuel assembly.

Effluent Disposal

512 The facilities provided on board for the storage of radioactive material obtained from the reactor systems and the method proposed for the removal and the subsequent storage ashore is to be submitted for approval.

513 In general, containment of all solid and liquid effluents is required and the design of equipment used to effect such containment for a period of three months full-power operation and to permit of its controlled discharge is to be submitted for approval.

Temporary storage and controlled discharge of innocuous concentrations of gaseous effluent is acceptable, subject to meeting national and international requirements.

Adequate monitoring devices for solid, liquid and gaseous effluent must be provided in all instances.

514 The designs and proposed method of operation of air circulating, air conditioning or air purging equipment in the containment structure are to be submitted for approval. The capacity of the equipment is to be related to the net volumes of the compartment and is to permit complete processing of such volumes in 30 minutes. All air before discharge is to be passed through a fission product clean-up unit.

Electrical Installations

515 Electrical installations are to be in accordance with Chapter M and, in addition, with the following Rules.

516 Limits of voltage and/or frequency between which equipment will operate satisfactorily are to be stated.

517 The electrical installation is to be such that failure of any component (e.g. generators, motors, bus bars, protective devices or cables) does not interrupt the supply to services essential for the safety of the ship.

518 Emergency supplies in the event of reactor shut-down and/or failure of main supplies must be stated.

Secondary Circuit

519 Secondary circuit equipment and machinery, other than primary and secondary heat exchangers, are to conform with the Society's Rule requirements. Power must be available to permit normal manœuvring of the ship and the flexibility of the system is to be shown to accommodate all variations in main engine demand.

The reactor transients under such conditions are to be submitted for examination.

Emergency Power

520 Unless two or more reactors capable of independent operation are fitted, an independent power supply separate from and independent of the nuclear machinery must be available. The power output of such machinery must maintain a ship's speed of not less than six knots.

A range of 1,000 miles (1600 kilometres) is recommended.

Shock

521 All reactor components are to be capable of withstanding an impact or shock acceleration of 3 g acting for a perceptible period of time in any direction using the yield stress or proof stress of the materials as a strength criterion.

Cleanliness

522 A high standard of cleanliness is to be maintained during construction of reactor components and their assembly into a hull. The methods and techniques required to obtain such a standard are to be submitted for approval.

Section 6

SURVEY AND MAINTENANCE

601 All proposed procedures for servicing and maintenance are to be included in the Operations Manual which is to be submitted for examination.

602 Hull and main machinery shall be subject to normal survey requirements.

603 All machinery used directly in conjunction with the reactor shall normally be subject to survey at four-yearly intervals, or at each refuelling period, whichever is the shorter.

604 The survey requirements for Category "A" pressure vessels and components will be given special consideration for each installation proposed.

605 The main steam generators and associated components in the containment which fall in Categories "B" and "C" (*see* 201), together with supports and seatings, shall be subject to survey at four-yearly intervals or at each refuelling period, whichever is the shorter.

606 Containment structures and supports are to be subject to survey at four-yearly intervals and a leak test is to be carried out at that time or in the event of minor modification or repairs to the pressure envelope. The leak test is to be carried out at 50 per cent of the major accident pressure, or at a lower agreed figure provided a leak rate/pressure curve has been determined.

607 An air test to the design pressure is to be carried out on a containment structure whenever a major modification or repair to the pressure envelope is made, or when significant deterioration of the envelope is noted.

608 Double bottom structure external to and in way of the containment vessel shall be subject to survey at four-yearly intervals or at each refuelling period, whichever is the shorter.

609 Primary and secondary shielding, together with associated parent structure, shall be subject to survey at four-yearly intervals or at each refuelling period, whichever is the shorter.

610 The design of the reactor installation should permit maintenance work, servicing and inspection to be carried out without excessive exposure of personnel to radiation hazards, which should not exceed permissible dose rates as laid down by the International Commission of Radiological Protection.

611 Containers for radioactive material are to be subject to examination by the Society's Surveyors at two-yearly intervals except that, where chemical decontamination is used or other severe conditions obtain, it may be required that more frequent examinations be effected.

29th April, 1965

R (D)—GUIDANCE NOTES ON METAL PIPES FOR WATER SERVICES

Section 1

PIPES FOR SEA WATER SERVICES

Types of Corrosion

101 The following types of accelerated corrosion have arisen with piping materials for sea water services:—

(a) Galvanic corrosion of the less noble metal where dissimilar metals were in association.

(b) Pitting corrosion, the main causes being local attack by deposits or transfer of small pieces of metal such as weld spatter, sulphides in polluted esturine waters, gassing in hot tubes of coolers, fouling and cathodic films in the bores of pipes as a result of incorrect methods of manufacture or fabrication.

(c) Corrosion-erosion where water speeds are excessive for particular metals. This may be particularly severe where turbulence occurs, e.g. protrusions in pipe bores, tight bends.

(d) Dezincification of some types of brasses including "manganese bronze".

(e) Stress corrosion cracking of copper-zinc alloys.

(f) Severe local corrosion due to sulphur and/or sulphide contamination of pipes.

(g) Cavitation erosion where water speeds are very high.

(h) Rusting of steel pipes when no protection has been applied or where protection has proved insufficient due to manufacturing fault or damage.

102 Metals differ in their resistance to these various forms of corrosion but even where corrosion resistant types have been used, inadequate attention to design detail or workmanship has caused failures. The following are recommendations for the selection of materials and practices.

Materials for Pipes and Flanges

103 Steel pipes should be protected against corrosion. Galvanising of the bores is the most common practice and is recommended as the minimum protection. All steel pipes of bilge and ballast lines should be galvanised.

Galvanised steel pipes should not be used for continuous service where water speeds exceed about 10 ft./sec. (3 metres/second).

The life of a galvanised coating depends on its thickness which to some degree is controlled by pipe thickness. In some cases, it may be advisable to use a pipe of heavier gauge. Welds should be free from lack of fusion and crevices. Where possible, the surfaces should be dressed to remove slag and spatter and, where possible, this should be done before galvanising. Preferably the coating should be continuous round the ends of the pipes and on the faces of flanges.

104 Rubber-lined steel pipes can give excellent service. The lining is resistant to all forms of corrosion and is particularly effective against scouring by sand. A good bond between the rubber lining and the steel of the pipe is essential. Preferably the rubber lining should be carried round the ends of the pipe and over the faces of the flanges to act as jointing material. There should be no discontinuities or pinholes in the lining, through which corrosion can occur and lift the coating. For these reasons rubber linings should be applied by specialist firms and care taken to avoid damage to finished coatings.

The foregoing comments also apply to plastic-lined pipes. Pipes with stoved coatings are also efficient, but care should be taken to avoid mechanical damage to flanges.

Coatings of the above types should be applied on completion of fabrication, i.e. forming and welding of steel pipes.

105 Copper pipes are particularly susceptible to perforation by corrosion-erosion. These pipes have given the greatest trouble in sea water systems. In some cases copper pipes have been replaced by galvanised steel pipes which have given superior performance.

The cause of the failures of copper pipes has been due mainly to the continuation of an established practice over a period when water speeds have increased appreciably. Low water speeds should be used with copper pipes and excessive local turbulence should be avoided.

106 Certain copper alloys have enhanced resistance to impingement attack and can be used where water speeds are higher than can be tolerated by copper. These alloys are as follows:—

Copper—30% Nickel—0·8% Iron Alloy.
Copper—10% Nickel—2% Iron Alloy.
Aluminium Brass.
Admiralty Brass.
Copper—5% Nickel—Iron Alloy.

In general, aluminium brass pipes and tubes give reliable service with reasonably clean sea water. For service with polluted river or harbour waters copper-nickel-iron alloy pipes and tubes are preferable. The nickel content of the alloy for these conditions should not be less than 10%. New copper alloy pipes should not be exposed initially to polluted water. Reasonably clean sea water should be used first in order that the metals can develop protective surface films.

107 Austenitic types of stainless steel are not recommended as they are prone to deterioration when in contact with polluted waters.

108 Where pipes are exposed to sea water on both external and internal surfaces, flanges should be made preferably of the same material. When sea water is confined to the bores of pipes the material of the flange is of less importance from the point of view of corrosion. However, flanges of the same or a less noble metal than that of the pipe, are recommended. Gunmetal flanges on aluminium brass pipes are an exception to this recommendation. Brass for flanges should be of the type containing 1·0% to 2·0% tin to minimise dezincification.

109 Fixed or loose type flanges may be used. The fixed flanges should be attached to the pipes by fillet welds or capillary silver-brazed joints as appropriate. Where welding is used, the fillet weld at the back should be a strength weld and that in the face a seal weld.

Where silver-brazing is used, strength should be obtained by means of the bond in a capillary space over the whole area of the mating surfaces. A fillet braze at the back of the flange or at the face is undesirable.

A combination of a silver-brazed joint at the front face and a normal brazed joint at the back face has given satisfactory service when the bore surface only was exposed to sea water.

110 With copper-nickel-iron alloy pipes, flanges of a similar type of alloy or of mild steel may be attached by argon arc welding. A mild steel flange should not be used when it will be in contact with sea water.

Copper, brass, bronze, gunmetal or copper-nickel-iron alloy flanges may be capillary silver-brazed to copper, aluminium brass or copper-nickel alloy pipes. "Bronze welding" should not be used. Brazing of inhibited alpha brass flanges to copper pipes using rods of a 92·75% copper–7·25% phosphorus alloy has given satisfactory service. The alloy used for silver-brazing should contain not less than 49% silver.

Mild steel flanges should be fusion welded or flash butt welded to mild steel pipes.

111 Alpha brasses must be properly inhibited against dezincification by suitable additions to the composition. Alpha-Beta brasses or those containing less than 70% copper should not be used for pipes and fittings.

Design Considerations

112 In sea water, galvanic corrosion may cause premature failure of a component when it is in contact with one of a more noble metal. For guidance, the Table gives the galvanic series for common metals in sea water. A metal in direct contact with one lower in the list may suffer accelerated corrosion in sea water.

TABLE 1

GALVANIC SERIES IN SEAWATER

Zinc
Aluminium
Carbon Steel
Cast Iron
Lead-Tin Solders
Lead
Brasses
Copper
Phosphor Bronze
Gunmetal
Copper-Nickel-Iron Alloys
Aluminium Bronze
Monel Metal

Where components are made from different metals, preferential corrosion of the less noble metal may be minimised by the introduction of a sacrificial anode. This is made of a metal which is higher in the Table than either of the working metals. Where a sacrificial anode is used to provide local protection, there should be an efficient electrical bond between it and the metal which it is to protect.

113 Water speeds should be carefully assessed at the design stage and the materials of pipes, valves, etc., selected to suit the particular conditions.

114 Attention should be given to the design, fabrication and installation of systems to ensure streamlined flow. In particular, abrupt changes in the direction of flow, protrusions into bores of pipes and other restrictions of flow should be avoided.

Pipe bores should be smooth and clean. Any carbonaceous films or deposits formed on the bore surfaces of non-ferrous pipes during bending processes should be carefully removed. Jointing should be flush with the bore surfaces of the pipes. Branches preferably should be set at a shallow angle to the line of the main piping, the junction should be smooth and the branch should not protrude into the bore of the main pipe. Tight bends should be avoided. The bore surfaces should be smooth at these positions and free from puckering.

115 Very low water speeds and stagnant zones should be avoided. Systems should not be left idle for long periods especially where the water may be polluted.

116 Strainers should be provided at the inlets to sea water systems.

117 Non-ferrous pipes which are fairly heavily cold worked during fabrication should be annealed or stress relief heat treated before they are put into service. Finished aluminium or Admiralty brass pipes, in particular, should not be overstrained to facilitate alignment and tight joints.

Section 2

PIPES FOR FRESH WATER SERVICES

201 The corrosive conditions in fresh water systems are less severe than in sea water systems and generally mild steel or copper pipes are satisfactory for service in fresh water applications.

202 Mild steel pipes should not be left idle for long periods if the water has a low salt content. This low salinity and the limited supply of oxygen promote the formation of black iron oxide on the bores of the pipes which gives rise to severe corrosion of the pipes. Where stagnant conditions are unavoidable steel pipes should be galvanised or pipes of suitable non-ferrous material should be used. Hot fresh water may promote corrosion of mild steel pipe unless the hardness and pH of the water are controlled.

203 Copper alloy pipes should be treated by scouring or other means to remove any harmful cathodic films from the bores before pipes and tubes are despatched from the Makers' Works.

204 Brass fittings and flanges in contact with water should be made of an alpha brass which is inhibited against dezincification.

205 Aluminium brass pipes and fittings are not recommended for fresh water services as, under certain circumstances (not yet completely defined), premature failure by pitting and/or cracking can occur.

21st May, 1964

R (E)—GUIDANCE NOTES ON TORSIONAL VIBRATION STRESSES AND CRITICAL SPEEDS FOR MAIN AND AUXILIARY OIL ENGINES

Section 1

GENERAL

101 In oil engine installations torsional critical speeds occurring between idling and full speeds are generally inevitable and these guidance notes are intended to safeguard machinery from the effects of excessive torsional vibration during the life of the ship.

The stress limits recommended provide reasonable margins to avoid shaft fatigue failure. Critical speeds at which the stress limits would be exceeded, should be avoided for continuous operation.

Careful attention, however, should be given to the dynamic system at the design stage to ensure, in particular, that significant critical speeds requiring "barred" ranges are avoided within the speed range(s) proposed for continuous operation in service. *See* 104 "Barred" Speed Ranges.

The stress limits set out in the following paragraphs should not be viewed necessarily as design values, but rather as values which should not be exceeded where critical speeds of appreciable importance cannot reasonably be avoided.

The stresses considered in these notes are nominal values based on the plain section of the shafting, excluding stress raisers.

Between 90 and 100 per cent of the maximum continuous speed, the stress limits apply to the sum of the vibratory stress due to any resonant order and stresses due to the dynamically magnified portions only of the flanks of other significant orders (i.e. subtracting the stresses due to the exciting torques).

Where critical speeds are found by calculation to show stresses approaching the limits, torsiograph records may be required. In practice, differences between calculated stresses and stresses measured by torsiograph or equivalent are frequently found. Where such differences arise, the stress limits are to be applied to the measured stresses.

The stress limits are applicable to steel shafts having a tensile strength of 28 to 33 tons/sq. in. (44 to 52 kg. per sq. mm.) For shafts of high tensile steel or other material, the stress limits will be subject to special consideration.

Where the scantlings of crank shafts, webs, couplings, coupling bolts and straight shafting are greater than required by the Rules, higher vibratory stress limits may be considered.

Engine Speed R.P.M.

102 Maximum continuous speed N_S may be defined as the maximum revolutions per minute for which the engines are classed in continuous operation.

In the case of constant speed generating sets for main propulsion or auxiliary purposes N_S is taken as the full load R.P.M.

Any special speed requirements for prolonged periods in service should be indicated, e.g. range of trawling R.P.M., range of operating R.P.M. with controllable pitch propeller, idling R.P.M., etc. Such speed ranges should be maintained clear of significant critical speeds so far as practicable.

Governor Control

103 For closely governed installations, the application of formulæ (4) and (8) may be restricted to revolutions 5 per cent higher than the governor control limit, with a minimum of $1{\cdot}10\ N_S$, provided such limit be demonstrated during engine trials.

"Barred" Speed Ranges

104 Where restricted speed ranges are imposed as a condition of approval, a notice board is to be displayed at the control station(s) stating that continuous operation should be avoided between the limits indicated by formulæ (2) and (6), and the tachometers marked accordingly. In such cases the tachometer accuracy should be checked against the counter readings, or by equivalent means, in the presence of the Surveyors to verify that it reads correctly within ± 2 per cent in way of the restricted range of revolutions.

Where vibration stresses due to criticals below $0{\cdot}8\ N_S$ marginally exceed the limiting stress for continuous operation, or where the critical speeds are sharply tuned, the range of revolutions restricted for continuous operation may be reduced.

Where such vibration stresses approach the limiting values f_t given in formulæ (3) and (7) the range of revolutions restricted for continuous operation may be extended, and the notice board(s) should indicate that this range must be passed through rapidly.

In cases where the resonance curve of a critical speed has been derived from torsiograph measurements, the range of revolutions to be avoided for continuous running may be taken as that over which the measured vibration stresses are in excess of the limiting stresses for continuous operation, having regard to the tachometer accuracy.

Excessive Vibration Stresses

105 In cases where vibration stresses exceed the limiting values, the dynamic system should be re-designed, or damping or detuning arrangements provided to remove the critical speed from the operating range or to reduce the magnitude of the vibration stress.

It is preferable to avoid the use of dampers or detuners to control criticals within the range between 0·85 and 1·05 N_S, but if fitted they should be of a type which makes adequate provision for dissipation of heat and contain no mechanical parts subject to deterioration in service.

Where dampers or flexible couplings are fitted, it may be required that torsiograph records be taken to verify their efficacy.

Gear Hammer

106 In installations having reversing and/or reduction gearing, or geared scavenge blowers, etc., where the vibratory torques at the gears exceed the mean transmission torques at the criticals considered, it may be necessary to impose a restricted range of revolutions in way of each critical speed at which gear hammer occurs.

Further, in the event of gear hammer being detected at speeds other than the calculated critical speeds, torsiograph records may be required to confirm the calculated natural frequencies.

In all cases where there is a possibility of gear hammer, the backlash in the gears should be kept to a minimum.

At critical speeds near the maximum speed the vibratory torque should not, in general, exceed one-third of the full transmission torque. In cases where the proposed loading on the gear teeth is less than the maximum allowable special consideration will be given to the acceptance of additional vibratory loading on the gears.

Screwshafts

107 The stress limits for screwshafts apply to fully protected shafts having a continuous liner with efficient sealing arrangements against corrosion of the shaft by sea water, and to shafts without liner which are oil lubricated and which are fitted with an approved type of oil gland.

In other cases special consideration will be necessary.

The limits are intended to apply to the minimum section of the shaft between the forward end of the propeller boss and the forward stern gland.

Intermediate Shafts

108 The stress limits for intermediate shafts apply to shafts having integral flanges with Rule fillet radii.

Where loose couplings are employed, the vibration stresses in the shaft in way of the coupling should be limited to 75 per cent of these values.

Definition of Symbols

109 In the formulæ for determining vibration stresses, the symbols used are as follows:—

N = engine speed R.P.M.

N_S = maximum continuous engine speed R.P.M. (*see* 102).

N_C = critical speed R.P.M.

r = ratio N/N_S or N_C/N_S whichever is applicable,

d = minimum shaft diameter considered, in inches or millimetres,

f_c = maximum value of the vibration stress for continuous running at or below maximum speed, in lb. per sq. inch or kg. per sq. cm.

f_t = maximum value of vibration stress due to criticals below 0·8 N_S necessitating restricted ranges, in lb. per sq. inch or kg. per sq. cm.

f = maximum value of the vibration stress above maximum speed, in lb. per sq. in. or kg. per sq. cm.

Propelling Machinery—Vibration Stress Limits

Crank and Screw Shafts

110 Where the critical occurs at or below the maximum R.P.M., vibration stresses not exceeding values given by the following formula are considered satisfactory for continuous running, viz:—

$$f_c = \pm(4500-80d)\,(1\cdot6-r^2) \quad \ldots\ldots(1)$$

or in metric units

$$f_c = \pm(315-0{,}22d)\,(1{,}6-r^2)$$

Where the vibration stresses exceed the limiting values for continuous running as given by formula (1) a notice board should be fitted at control stations stating that the engine should not be run continuously between the following speed limits, above and below the critical speed, and the engine tachometers should be marked correspondingly, viz:—

Range of engine R.P.M. to be avoided:—

$$\text{From } \frac{16\,N_C}{(18-r)} \text{ to } \frac{(18-r)\,N_C}{16} \text{ inclusive} \quad \ldots\ldots(2)$$

The maximum values of the vibration stresses due to such criticals should not exceed those given by the following formula, viz:—

$$f_t = 2\,f_c \quad \ldots\ldots(3)$$

Criticals should be arranged sufficiently removed from the maximum R.P.M. to ensure that, in general, at $r = 0\cdot8$ the stress due to the upper flank does not exceed f_c (formula (1)).

Where the critical occurs above the maximum R.P.M., the vibration stresses should not increase beyond values

given by the following formula at revolutions up to 1·16 times the maximum R.P.M., viz:—

$$f = \pm (2700-48d)\left(1 + 5\sqrt{r-1}\right) \quad \text{.....(4)}$$

or in metric units

$$f = \pm (190-0{,}13d)\left(1 + 5\sqrt{r-1}\right)$$

Intermediate and Thrust Shafts

111 Where the critical occurs at or below the maximum R.P.M., vibration stresses not exceeding the values given by the following formula are considered satisfactory for continuous running, viz:—

$$f_c = \pm (7600-80d)(1{\cdot}44-r^2) \quad \text{.....(5)}$$

or in metric units

$$f_c = \pm (535-0{,}22d)(1{,}44-r^2)$$

Where vibration stresses exceed the limiting values for continuous running as given by formula (5), a notice board should be fitted at control stations stating that the engine is not to be run continuously between the following speed limits, above and below the critical speed, and the engine tachometers should be marked correspondingly, viz:—

Range of engine R.P.M. to be avoided:—

$$\text{From } \frac{16\,N_c}{(18-r)} \text{ to } \frac{(18-r)\,N_c}{16} \text{ inclusive} \quad \text{.....(6)}$$

The maximum values of the vibration stresses due to such criticals should not exceed those given by the following formula, viz:—

$$f_t = 1{\cdot}7\,f_c \quad \text{.....(7)}$$

Criticals should be arranged sufficiently removed from the maximum R.P.M. to ensure that, in general, at $r = 0{\cdot}8$ the stress due to the upper flank does not exceed f_c (formula (5)).

Where the critical occurs above the maximum R.P.M., the vibration stresses should not increase beyond values given by the following formula at revolutions up to 1·16 times the maximum R.P.M., viz:—

$$f = \pm (3340-35d)\left(1+5\sqrt{r-1}\right) \quad \text{.....(8)}$$

or in metric units

$$f = \pm (235-0{,}097d)\left(1+5\sqrt{r-1}\right)$$

Auxiliary Machinery and Propulsion Oil Engine driven Generators

112 The following notes are applicable to oil engines developing 150 b.h.p. or 100 kW. and over, driving auxiliary machinery used for essential services and to propulsion oil engine driven generating sets operating at constant speed.

The dynamic system comprising engine and driven machinery should be so designed that vibration stresses in the crank shafts and transmission shafting resulting from critical speeds do not exceed values given by the following formula within speed limits of ·95 and 1·10 N_S, N_S being the full load R.P.M., viz:—

$$f_c = \pm (3000-50d) \quad \text{.....(9)}$$

or in metric units

$$f_c = \pm (212-0{,}14d)$$

Vibration stresses in the crankshaft and transmission shafting due to critical speeds which have to be passed through in starting and stopping should not exceed values given by the following formula, viz:—

$$f_t = 5{\cdot}5f_c \quad \text{.....(10)}$$

It is also recommended that the vibration torques applied to generator rotors should be reduced to the lowest possible value and, in any case, should be limited to not more than twice full load mean torque over the range ·95 and 1·10 N_S and not more than six times full load mean torque in passing through criticals below 0·95 N_S. In the former case the vibration torque should be taken as the sum of the torques due to any resonant order and the dynamically magnified portions of the flanks of other significant orders. These recommendations are designed to protect the generator rotor structure from excessive inertia torques.

In cases where the generator rotor is designed for a higher rating than that applied by the engine, the higher rating can be taken as the criterion.

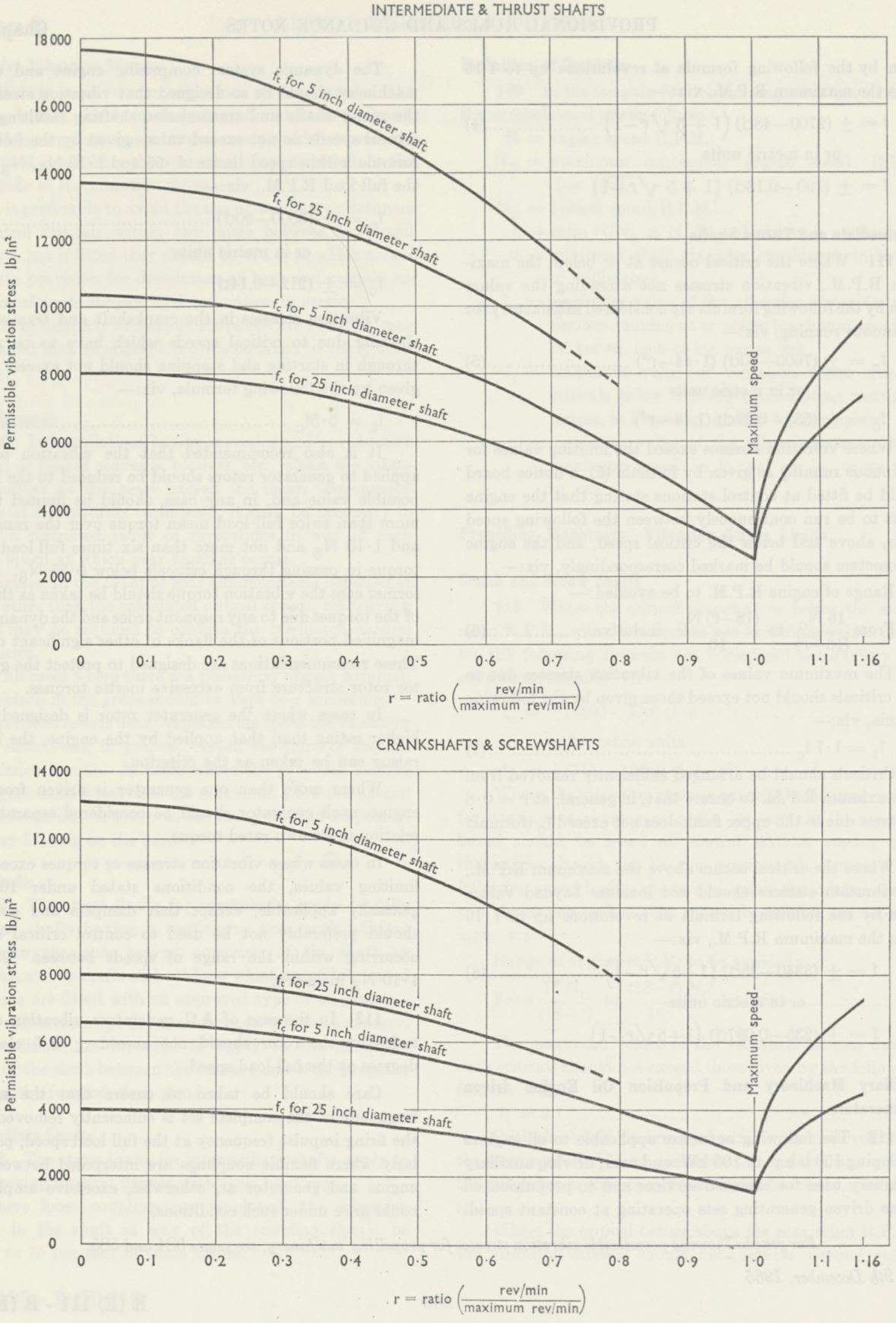
Where more than one generator is driven from one engine, each generator should be considered separately in relation to its own rated torque.

In cases where vibration stresses or torques exceed the limiting values, the conditions stated under 105 are generally applicable, except that dampers and detuners should preferably not be used to control critical speeds occurring within the range of speeds between ·95 and 1·10 N_S inclusive.

113 In the case of A.C. generators vibration amplitudes on the rotor should not exceed ± 2·5 electrical degrees at the full load speed.

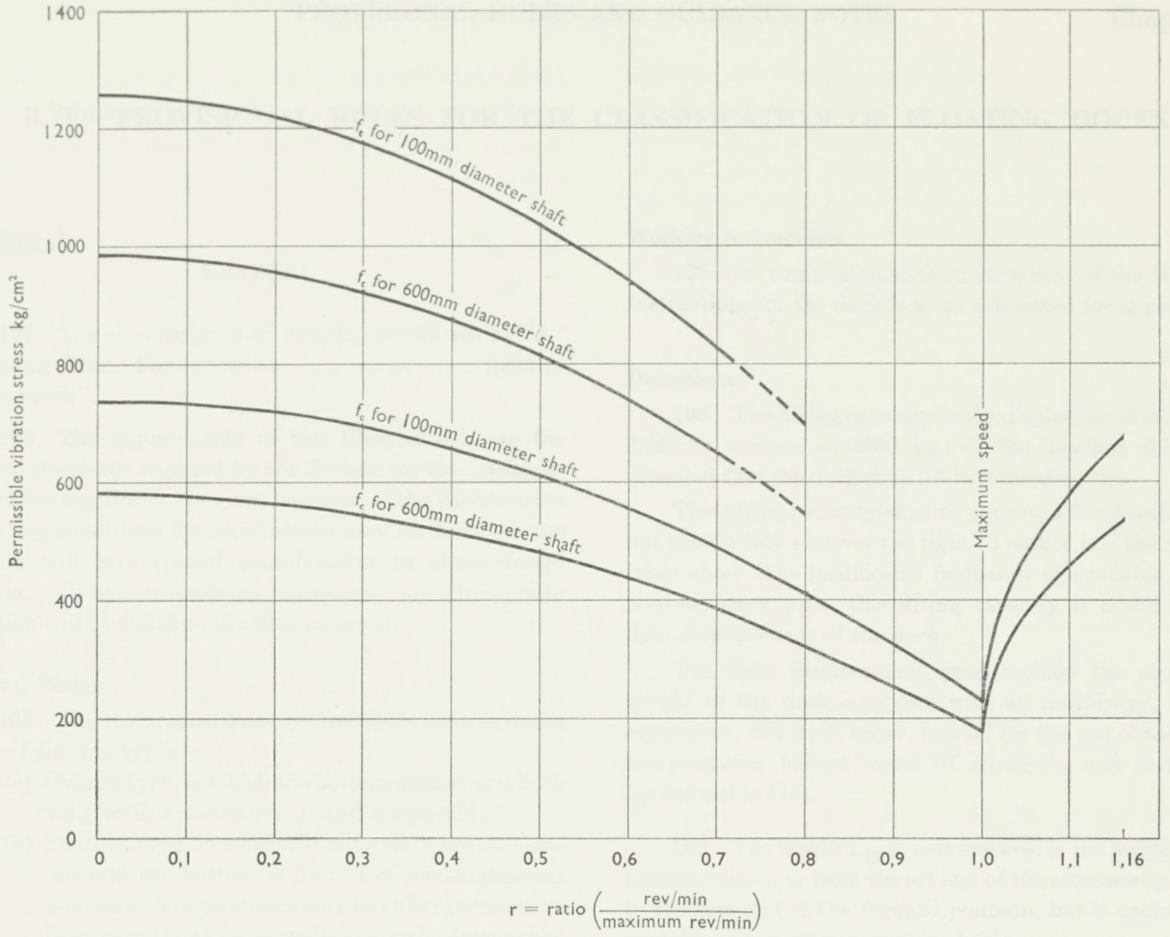
Care should be taken to ensure that the natural frequency of the complete set is sufficiently removed from the firing impulse frequency at the full load speed, particularly where flexible couplings are interposed between the engine and generator as, otherwise, excessive amplitudes could arise under such conditions.

For graphs showing permissible vibration stresses for propelling machinery, see pages 584 *and* 585.

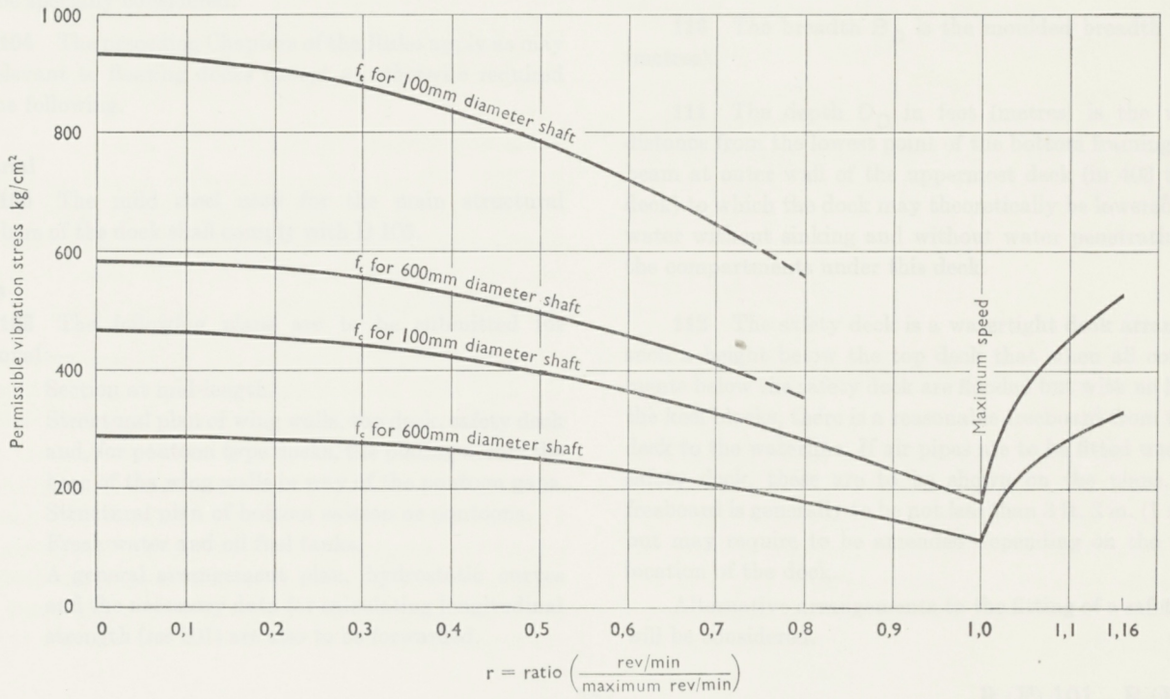


Permissible Vibration Stresses for Propelling Machinery. (British Units)

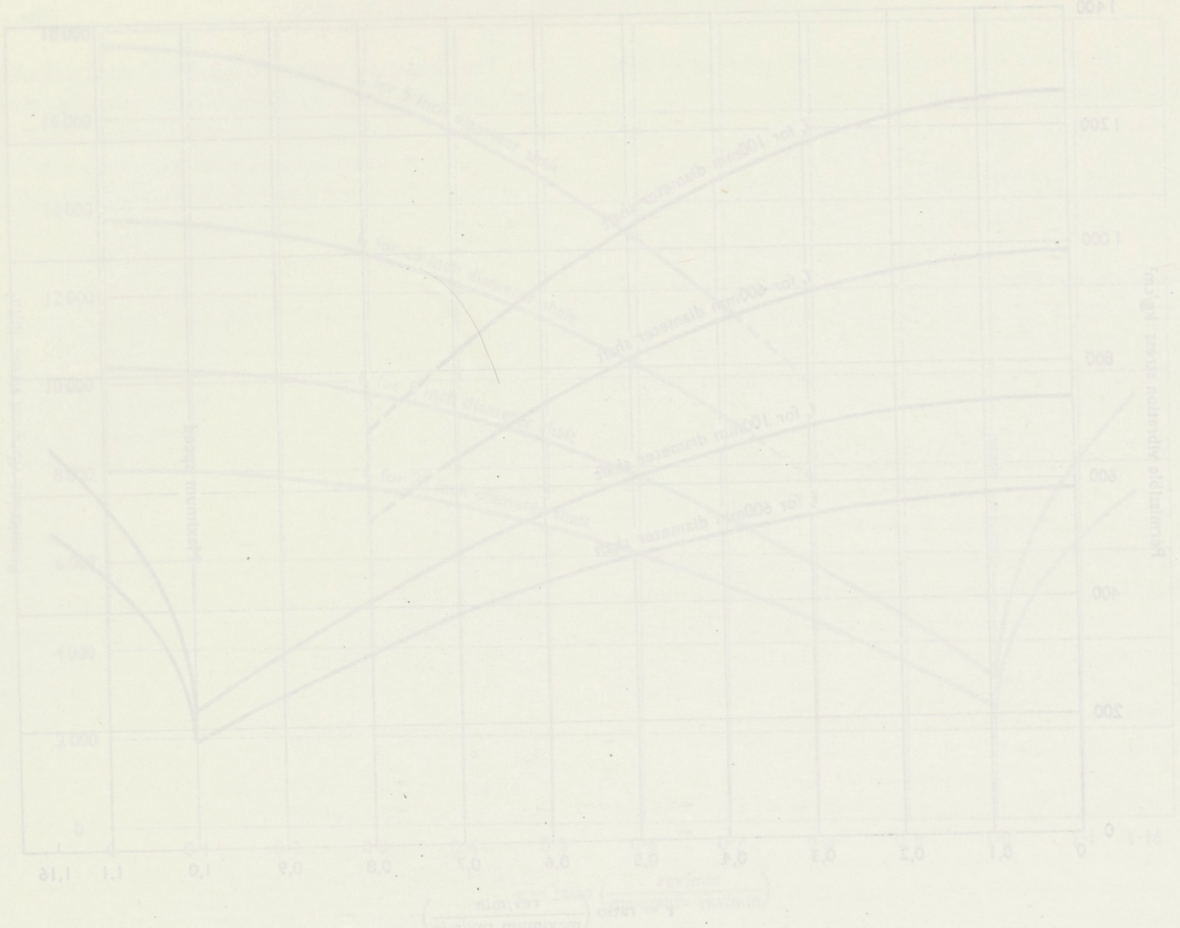
INTERMEDIATE & THRUST SHAFTS

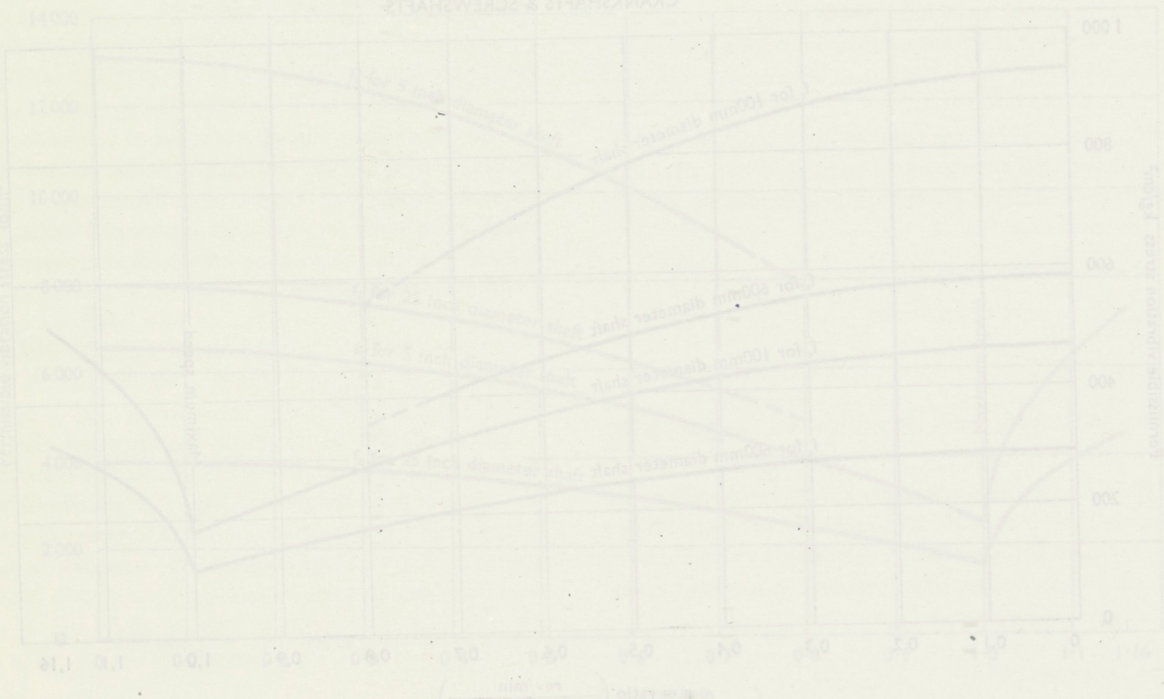


CRANKSHAFTS & SCREWSHAFTS



Permissible Vibration Stresses for Propelling Machinery. (Metric Units)





R (F)—PROVISIONAL RULES FOR THE CLASSIFICATION OF FLOATING DOCKS

Section 1

GENERAL

Class

101 The class assigned to Floating Docks will be "A" "Floating Dock. For service at ..... (port to be specified)".

102 The requirements of this Chapter indicate the general standards required by the Society for the classification of floating docks. In view, however, of the variations in operating conditions for which docks may be designed, the Society will give special consideration to other design criteria. Where considered necessary, an appropriate notation will be added to the class assigned.

General Design

103 The requirements apply directly to floating docks of the following types:—

(a) Caisson type, in which the bottom caisson and both wing walls are continuous and inseparable.

(b) Pontoon type, in which the wing walls are continuous and the bottom is formed of non-continuous pontoons. The pontoons may be either permanently attached to the wing walls or may be detachable.

The scantlings and arrangements of docks of other types will be specially considered.

104 The preceding Chapters of the Rules apply as may be relevant to floating docks except as otherwise required by the following.

Material

105 The mild steel used for the main structural members of the dock shall comply with D 103.

Plans

106 The following plans are to be submitted for approval:—

Section at mid-length.

Structural plan of wing walls, top deck, safety deck and, for pontoon type docks, the plating across the base of the wing walls in way of the pontoon gaps.

Structural plan of bottom caisson or pontoons.

Fresh water and oil fuel tanks.

A general arrangement plan, hydrostatic curves and the necessary data for calculating longitudinal strength (*see* 201) are also to be forwarded.

Working Instructions

107 On completion of the dock a copy of the Working Instructions for the dock is to be submitted for approval.

Definitions

108 The lifting capacity is the displacement in tons of 2,240 lb. (tonnes of 1000 kg.) of the heaviest ship it is intended that the dock shall lift in normal service.

This lifting capacity shall be approved for classification, but the Society reserves the right to reduce it if the sinkage trials show that insufficient freeboard is available at the pontoon deck when this lifting capacity is added to the light displacement of the dock.

The light displacement shall include the structural weight of the dock complete with all machinery, cranes, equipment, full fresh water, fuel oil for the use of the dock, compensating ballast water (if required), and rest-water (as defined in 115).

109 The length L_D in feet (metres) is the length of the bottom caisson or from the aft end of the aftermost pontoon to the fore end of the forward pontoon, but is exclusive of portable end platforms or swing bridges.

Amidships is to be taken as the middle of the length L_D.

110 The breadth B_D is the moulded breadth in feet (metres).

111 The depth D_D in feet (metres) is the vertical distance from the lowest point of the bottom framing to the beam at outer wall of the uppermost deck (in 403 the top deck) to which the dock may theoretically be lowered in the water without sinking and without water penetrating into the compartments under this deck.

112 The safety deck is a watertight deck arranged at such a height below the top deck that when all compartments below the safety deck are flooded but with no load on the keel blocks, there is a reasonable freeboard from the top deck to the waterline. If air pipes are to be fitted under the safety deck, these are to be shown on the plans. This freeboard is generally to be not less than 3 ft. 3 in. (1 metre), but may require to be amended depending on the service location of the dock.

Alternative arrangements to the fitting of a safety deck will be considered.

113 The freeboard to the pontoon deck at the centre-line of the dock when supporting a ship whose displacement is the lifting capacity (as defined in 108) shall be not less than 12 inches (300 mm.). When the pontoon deck at the inner side walls is lower than at the centre, the freeboard to the pontoon deck at the inner side walls shall be not less than 3 inches (75 mm.) and the freeboard at the centre line shall be not less than 12 inches (300 mm). These freeboards assume the travelling cranes are positioned to give no trim; the freeboard at level trim shall be such that when both cranes are moved to the forward end or to the after end of the dock, the pontoon deck shall not be submerged. These freeboards shall depend also on the location of the dock.

114 The length L_S in feet (metres) is the length between perpendiculars of the shortest ship whose displacement is equal to the lifting capacity of the dock (as defined in 108), the breadth and draught of the ship being the maximum the dock can accommodate, and the block coefficient assumed to be 0·80. The length so calculated may have to be adjusted to give realistic proportions and, in general, the breadth B assumed need not be taken as greater than that corresponding to the following proportions:—

L_S (feet)	190	260	330	400	460	520	580	640	710	780	850	920
L_S (metres)	60	80	100	120	140	160	180	200	220	240	260	280
L_S/B	5·7	6·2	6·7	7·2	7·2	7·2	7·2	7·2	6·8	6·4	6·0	5·6

115 The rest-water is the ballast water in the tanks which the pumps cannot discharge.

116 Compensating ballast water is ballast water which may be used to control the deflection of the dock under longitudinal bending. Rest-water is not included in compensating ballast water.

Section 2

LONGITUDINAL STRENGTH

General

201 The longitudinal strength is to be calculated for the condition when the ship of length L_S (described in 114) is supported on the keel blocks, the centre of the ship's length being over the mid-length of the dock, and the freeboard at the pontoon deck is as described in 113. The level of ballast water is to be constant over the length L_D (as defined in 109).

Ship Weight Curve

202 The weight curve of the ship is to be taken as a rectangle under a parabola of equal area, the length of each area being L_S.

Bending Moments

203 The conditions described in 201 and 202 will result in a sagging bending moment, the units being tons–feet (tonnes–metres).

Modulus of Section

204 The material to be included in the calculation of the section modulus will be, for the caisson type dock, all continuous fore and aft material of the whole dock (i.e., wing walls structure and bottom pontoon).

For the pontoon type dock all continuous fore and aft material of the wing walls structure may be included together with the fore and aft material of the parts of the pontoon which are directly under the wing walls structure (i.e., material of pontoon lying between the lines of the inner walls is not included in the modulus calculation for this type of dock). At the section in way of the gap between pontoons, all continuous fore and aft material of the wing walls structure may be included, together with the horizontal plate across the base of the outer and inner walls, provided this plate extends longitudinally at least 78 inches (2 metres) over each pontoon.

The modulus of section calculation is to be included with the longitudinal strength data (*see* 106). The modulus units are to be in inches^2 feet (cm.^{3}).

See also 207.

Permissible Stresses

205 When it is intended that the normal operation of the dock shall be with ballast water evenly distributed over its entire length, the stress in the bottom or deck, computed from the data in 203 and 204, is not to exceed 7 tons per sq. inch (1100 kg. per cm.^{2}).

206 When it is intended that the normal operation of the dock shall be by differential emptying of the ballast compartments, the stress with the ballast water suitably distributed shall be in accordance with 205.

In addition, the section modulus of the dock shall be not less than that required to ensure that the stress does not exceed 11 tons per sq. inch (1730 kg. per cm.^{2}) when the ballast water (of the amount used in the condition described in the preceding sub-paragraph) is evenly distributed over the length of the dock.

207 An approximate value of the section modulus required to give the permissible stress may be derived from the formula:—

$$\text{Section modulus} = \frac{\text{L.C.}}{8f}(cL_D - 0{\cdot}875L_S) \text{ inches}^2 \text{ ft.}$$

where L.C. = the lifting capacity of the dock in tons,

L_D = the length of dock (*see* 109) in feet,

L_S = the length of ship (*see* 114) in feet,

f = either 7 tons per sq. inch or 11 tons per sq. inch, the permissible stress (*see* 205 and 206),

c = 1·0 for caisson type docks

and $c = a + \frac{nb}{n-1}$ for pontoon type docks,

where n = number of pontoons,

a = fraction of length of dock taken up by pontoons,

and b = fraction of length of dock taken up by gaps between pontoons,

or in metric units:—

$$\text{Section modulus} = \frac{12500 \times \text{L.C.}}{f}(cL_D - 0{,}875\ L_S) \text{ cm.}^3$$

where L.C. = lifting capacity of the dock in tonnes (of 1000 kg.),

L_D = length of dock (*see* 109) in metres,

L_S = length of ship (*see* 114) in metres,

f = either 1100 kg. per cm.^{2} or 1730 kg. per cm.^{2}, the permissible stress (*see* 205 and 206),

c = 1,0 for caisson type docks

and $c = a + \frac{nb}{n-1}$ for pontoon type docks,

where n = number of pontoons,

a = fraction of length of dock taken up by pontoons,

and b = fraction of length of dock taken up by gaps between pontoons.

208 Where the dock has to be towed in open waters from the port of construction to the port of operation, the total permissible stress en route is not to exceed 11 tons per sq. inch (1730 kg. per cm.^{2}). The designer's calculations of this stress are to be submitted. The wave conditions should assume a length of wave equal to L_D and height of wave the maximum expected to be encountered during the voyage in tow.

Extent of Scantlings

209 The scantlings of members included in the modulus calculation (*see* 204) shall be maintained over 20 per cent of the length of the dock L_D on each side of the longitudinal middle of the dock.

Deflection Meters

210 Two different types of deflection meter are to be fitted, the readings to be shown on an indicating board in the control rooms.

The meters shall be of the electrical and optical types and the deflections shall be obtained over the length of the dock L_D. The deflection corresponding to a stress of 7 tons per sq. inch (1100 kg. per cm.^{2}), when lifting the ship defined in 114, shall be stated in the Working Instructions. (*See* 107).

Alternative means of recording deflection will be specially considered.

Section 3

TRANSVERSE STRENGTH

General

301 The transverse strength is to be calculated, for the condition described in 201, at the centre of the length of the dock and towards the ends of the dock using the ship weight curve described in 202, and the modulus so required (*see* 303) is to be applied throughout the length of the dock.

Bending Moment

302 The bending moments on the transverses of the bottom caisson or pontoons are to be evaluated for the above condition and positions in tons–feet (tonnes–metres) units.

Modulus of Section

303 The material to be included in the calculation of the section modulus of a transverse will be the continuous athwart dock material associated with the transverse. The effective width of pontoon deck and of pontoon bottom plating to be taken with the transverse is to be calculated from the information given in D 5303.

Permissible Stresses

304 The compressive and tensile stresses computed from 302 and 303 are not to exceed 11 tons per sq. inch (1730 kg. per cm.^{2}).

Section 4

LOCAL STRENGTH

General

401 Plating and supporting stiffeners designed to meet the requirements of 205, 206, 208 and 304 may require to be increased to satisfy local strength requirements. Alternative means of computing scantlings to meet these requirements may be used when a copy of such calculations is to be submitted.

Tank Plating and Stiffeners

402 The thickness of plating and scantlings of stiffeners in ballast tanks, oil tanks, fresh water tanks and sewage tanks are to be obtained from Chapter D, Tables 32 and 40 respectively. For ballast tanks the pressure head to be used in association with these Tables is to be that obtained from an analysis of the hydrostatic curves.

Top Deck Plating

403 The thickness of plating for the middle 40% of the length is to be as required for longitudinal strength. For 10% of the length L_D at each end of the dock the thickness may be 0·25 inch, (6,5 mm.) [with an increase of 3% for every inch (25 mm.) that the spacing of longitudinals exceeds 24 inches (610 mm.)], unless local conditions require a greater thickness. For the intermediate lengths (each of 20% of the dock length) the thickness of the deck will be given proportionate values.

Top Deck Longitudinals

404 It is assumed the top deck will be stiffened longitudinally for the middle 40% of the length. The scantlings of longitudinals will generally be those required to obtain the area necessary for the section modulus derived from longitudinal strength considerations but shall be not less than specified below for longitudinals at the ends.

For 10% of the length L_D at each end of the dock the scantlings of the longitudinals are to be such that the stress under a loading of 300 lb. per sq. ft. (1465 kg. per sq. metre) does not exceed 7 tons per sq. inch, (1100 kg. per sq. cm.) the loading may require to be increased to suit the general arrangement of a particular dock.

The scantlings of the longitudinals in the intermediate length are to be intermediate between those required for the middle and end portions.

Safety Deck Plating

405 The thickness of plating of this deck, with the exception of those areas covered by 402, shall be in accordance with Chapter D, Table 32 and associated notes using a depth 70 per cent of the height between decks (top of safety deck beam to top of top deck beam at side). This assumes a stowage rate of 50 cubic feet per ton (1,39 cubic metres per 1000 kg.); where the stowage rate exceeds this value the depth to be used is to be increased proportionately. When air pipes project into the ballast tanks (*see* 501), it may be that the head corresponding to the maximum pressure in the air cushion will exceed the above value of the depth; in this case the depth used will be that corresponding to the air cushion pressure.

Safety Deck Beams

406 The beams under the safety deck, with the exception of those areas which are covered by 402, shall be in accordance with Chapter D, Table 40 and associated notes; the head H is to be used in this context being the value of the depth obtained as described in 405.

Framing

407 Framing of side walls, bottom, and pontoon deck shall be in accordance with Chapter D, Table 40 and associated notes, the head H being obtained from an analysis of the hydrostatic curves.

Transverses and Web Frames

408 The spacing of deep transverse beams, deep side frames and bottom transverses is not to exceed 16 feet, (5 metres).

The loadings on the deck transverses are to be in accordance with 402, 404 or 406, whichever is applicable. The width of deck supported by the transverse shall be the width between the inner and outer side walls and the length shall be the spacing of transverses.

The loading on deep side frames and bottom transverses shall be obtained from an analysis of the hydrostatic curves.

The permissible stress in transverses and deep frames shall be 5 tons per sq. inch (787,5 kg. per cm.^{2}).

Cross Ties

409 Cross ties when fitted between the inner and outer wing walls shall be in accordance with D 4901, the value of h being obtained from an analysis of the hydrostatic curves.

Watertight Bulkhead Plating and Stiffeners

410 Pontoon centre line girder, when watertight, and watertight side girders shall be in accordance with 402. The strength of these items must also be considered in conjunction with the requirements of 412.

Non-Watertight Bulkheads

411 Non-watertight girders in pontoon. The thickness of plating is to be ·30 inch (7,5 mm.). The scantlings of stiffeners are to be determined from Chapter D, Table 39 and associated notes; the numeral is to be determined by

$$\cdot 0143 \times s \times b \times h$$

where s = the spacing of the stiffeners in feet

b = the mean width of pontoon deck or bottom plating, measured transversely and in feet, supported by the girder,

h = the head of water in feet, obtained from an analysis of the hydrostatic curves, to which the pontoon deck and bottom plating is subjected

or in metric units, the numeral is to be determined by

$$1{,}43 \times s \times b \times h$$

where s = the spacing of the stiffeners in metres,

b = the mean width of pontoon deck or bottom plating, measured transversely and in metres, supported by the girder,

h = the head of water in metres, obtained from an analysis of the hydrostatic curves, to which the pontoon deck and bottom plating is subjected.

The strength of these items must also be considered in conjunction with the requirements of 412.

Keel Blocks and Supporting Structure

412 The loading to be taken (over the whole length of the dock) by the keel blocks and supporting structure shall be $\frac{1 \cdot 25}{L_S} \times$ the lifting capacity, in tons per linear foot (tonnes per linear metre).

Platforms Extending from Ends of Dock

413 The loading on these structures is assumed to be 120 lb. per square foot (586 kg. per square metre). If a heavier loading is anticipated or required, the plans are to be marked accordingly.

Swing Bridges at End of Dock

414 The loading on this connecting bridge is assumed to be 75 lb. per square foot (366 kg. per square metre). If a heavier loading is anticipated or required, the plan is to be marked accordingly.

Section 5

ADDITIONAL ITEMS

Air Pipes under Safety Deck

501 The maximum draught of the dock (*see* 112) may be controlled by fitting air pipes under the safety deck and/or the centre pontoons. The length of these pipes will be dependent on the extent of the cushion of air desired. The pipes are to be of substantial thickness and rigidly supported in place.

Cranes

502 The structure of travelling cranes on the top deck is not included in the Society's survey unless specially desired.

The all-up weight of cranes, arrangement of wheels and rails are to be indicated on the plans, so that local strength requirements due to these loads may be taken into account.

Manholes

503 Sufficient manholes are to be cut in the safety deck, pontoon deck, transverses and girders in pontoons to provide adequate ventilation and access to all parts of the structure. The edges of holes are to be smooth. *See also* D 528.

Cofferdams

504 Compartments carrying oil are to be separated by cofferdams from those carrying fresh water. Cofferdams are to be suitably ventilated.

Coating

505 Particular attention is to be paid to the coating of the underwater portion of the dock. Full particulars are to be submitted for approval.

Section 6

TESTING

General

601 Each ballast tank, oil tank, and fresh water tank and cofferdam, is to be separately tested by filling with water to the test head.

When water testing on the building berth may be undesirable, testing may be carried out afloat, provided any riveted shell seams in the bottom plating are tested with a

high pressure hose on the berth. The testing afloat is to be so arranged that each tank can successively be examined whilst being subjected to a head of water equal to the maximum operational head as found from the hydrostatic curves.

When a preservative coating is to be applied to the internal structure of a tank, the water testing may take place after the application of the preservative, provided the structure is carefully examined to ensure that all welding and structural stiffening are completed prior to the application of the coating, and any riveted shell seams are tested with a high pressure hose on the berth before coating. The hose test of the riveted seams may be carried out from the outside to avoid wetting the tank structure.

The cause of any discoloration or disturbance of the coating is to be ascertained and any deficiencies repaired.

Compartments above the safety deck may be tested to an air pressure of $3\frac{1}{2}$ lb. per square inch, (0,25 kg. per square cm.). Precautions are to be taken to ensure that this pressure is not exceeded.

Test Head

602 The test head for ballast tanks, as mentioned in the first sub-paragraph of 601 is to be 20 inches (500 mm.) above the top deck at side, but need not exceed twice the pressure head determined in accordance with 402.

Sinkage Trials

603 On the completion of the dock, sinkage trials shall be carried out in the presence of the Society's Surveyor. Fresh water tanks and the dock's fuel tanks shall be full, but ship-oil tanks are to be empty. The travelling cranes may be so positioned that the draughts forward and aft are equal. The density of the water shall be recorded.

(*a*) *Normal Condition.* All ballast water shall be emptied as far as possible, only rest-water remaining. The draughts forward and aft, port and starboard, shall be recorded. The readings on deflection meters shall be taken. The deflection of the dock along the top of keel blocks shall be measured.

Adjustment of the meters shall then be made, if necessary, so that they record this built-in permanent deflection in the normal condition. The light displacement shall be evaluated from these readings, and to obtain the light displacement, as defined in 108, the weight of any compensating ballast water must be added.

(*b*) *Sagging Condition.* Equal amounts of water shall be admitted to corresponding tanks on either side of the middle of the length, the depths increasing until the greatest depth is in the tanks at the middle of the length. The sagging bending moment so produced shall equal that evaluated in 203. The deflection meter readings shall be recorded and, by allowing for the permanent deflection, *see* sub-para. (*a*), the sagging deflection will be obtained.

Alternative arrangements to those described in (*b*) above will be specially considered.

604 When estimating the quantities of ballast water for 603 (*b*), the permissible difference in height of ballast water in adjacent compartments shall not exceed the pressure head for the compartments as laid down in 402.

Section 7

MACHINERY INSTALLATIONS

General

701 Items of machinery, such as boilers, pressure vessels, auxiliary engines, compressors, pumps, etc., essential to the operation of a floating dock are to be constructed and installed in general accordance with the relevant requirements of the Rules.

702 Fire extinguishing appliances, pumping arrangements, oil fuel and other piping systems are to be provided in accordance with the Rules so far as they may be applicable to floating docks.

703 The arrangements for discharging water ballast are to be such that not less than two pumps are available for pumping out each buoyancy compartment.

Electrical Installations

704 Electrical equipment constructed in accordance with the Rules will be accepted. Alternatively, consideration will be given to the acceptance of equipment constructed in accordance with a national or international standard for industrial equipment. In the latter case due consideration is to be given to the ambient temperature and other ambient conditions expected in service and the necessary adjustments made to such items as permissible temperature rise.

705 In all other respects, e.g., the system of distribution, the installation is to comply with normal good electrical engineering practice and Chapter M is to be used as a guide for this purpose.

706 The following is to be carried out by the Surveyors and in accordance with Chapter M:—

(i) Inspection and testing of electrical equipment.
(ii) Installation of electrical equipment.
(iii) Final testing of the electrical installation.

Plans

707 All necessary plans are to be submitted for approval before work is commenced.

Section 8

PERIODICAL SURVEYS

Annual Surveys

801 Docks should be surveyed afloat at intervals of approximately one year.

Special Surveys

802 Docks are to be subjected to Special Surveys at four-yearly intervals, the first four years from the date of build and thereafter from the date of the previous Special Survey.

PERIODICAL SURVEY REGULATIONS
HULL

Annual Surveys

803 The Surveyor is to satisfy himself as to the efficient condition of the following:—

Pontoon, safety and top working decks, exposed inner walls, shell plating above the light waterline, keel blocks and their foundations, casings, skylights, companionways and ladders, hatchways and manholes with their closing and securing arrangements, exposed self-docking connections, hinged gangways, mooring attachments, air pipes and overboard scuppers and discharges, guard rails and stanchions and rubbing fenders.

Special Surveys

804 The full requirements of an Annual Survey are to be complied with together with the following:—

The spaces between the safety and top working decks are to be cleared and cleaned as necessary and examined, lining and pipe casings are to be removed as required.

805 The Surveyor may require to ascertain by drilling or other approved means the thickness of the materials in any portion of the structure where signs of wastage are evident or wastage is normally found. Any parts of the structure which are found defective or materially reduced in scantlings are to be made good by materials of the approved scantlings and quality. Surfaces are to be recoated as necessary.

806 Where the inner surface of the bottom plating is covered with cement, asphalt or other composition the removal of this covering may be dispensed with, provided it be inspected, tested by beating or chipping, and found sound and adhering satisfactorily to the steel.

Pontoon and side wall tanks are to be cleaned and examined internally and tested by a head sufficient to give the maximum pressure that can be experienced in service.

807 Wood deck sheathing is to be examined and if decayed or rot is found or the wood is excessively worn it should be renewed. Attention is to be given to the condition of the plating under the sheathing or other deck covering. If it is found that such coverings are broken or not adhering closely to the plating, sections should be removed as necessary to ascertain the condition of the plating.

808 For floating docks not more than 15 years old oil fuel tanks forming part of the main structure need not be examined internally. When examining tanks internally the Surveyor is to satisfy himself as to the condition of the pump suctions.

809 The Owners' proposals for examination of the underwater portion of the dock are to be submitted for consideration.

810 At the first Special Survey after the dock is 24 years old and at every 12 years thereafter or at the next Special Survey after the expiration of the latter period, the full requirements of a Special Survey stated above are to be complied with together with the following:—

In addition to the drilling required to ascertain local wastage the outside plating of the walls and pontoons are to be gauged by drilling or other approved means to determine the amount of any general diminution in thickness. The gauging is to be done in at least two places in each strake of plating on each side within the amidship half length.

All paint and rust is to be entirely removed before the plates are gauged by the Surveyor and the actual thicknesses are to be reported in detail. Where drilled plates are renewed the thickness of adjacent plates in the same strake should be reported.

MACHINERY INSTALLATION

811 For maintenance of class the boilers, machinery and electrical installations are to be submitted to periodical surveys in accordance with the relevant requirements of Chapters B and C, so far as these are applicable.

28th January, 1965

812 Where practicable, all sea connections should be opened up as part of the machinery survey but the Committee will be prepared to consider alternative proposals having regard to the circumstances of each case, provided full particulars are submitted.

R (G)—RECOMMENDATIONS FOR PROPELLER-HULL CLEARANCES

Symbols

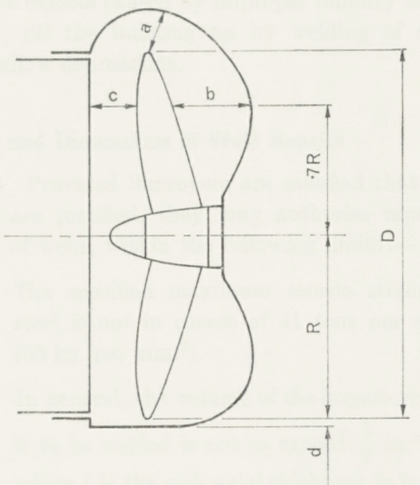
101 D = propeller diameter, in feet (metres).
R = propeller radius, in feet (metres).
L = length of ship, in feet (metres).

General

102 The following recommendations indicate the minimum clearances between the propeller and sternframe, rudder or hull that should be provided to minimise the possibility of propeller excited vibration.

SINGLE SCREW SHIPS

103 The clearances between the propeller and the rudder or sternframe should not be less than given in the Table.



NUMBER OF BLADES	a*	b*	c*	d
3	$1{\cdot}2k_1D$	$1{\cdot}8k_1D$	·12D	·03D
4	k_1D	$1{\cdot}5k_1D$	·12D	·03D
5	$·85k_1D$	$1{\cdot}275k_1D$	·12D	·03D
6	$·75k_1D$	$1{\cdot}125k_1D$	·12D	·03D

where

$$k_1 = \left(0{\cdot}1 + \frac{L}{10000}\right)\left(\frac{22{\cdot}4\ SHP}{L^2} + {\cdot}3\right)$$

$$\left(k_1 = \left(0{,}1 + \frac{L}{3050}\right)\left(\frac{2{,}05\ SHP}{L^2} + 0{,}3\right) \text{ metric}\right)$$

SHP = maximum designed shaft horse power.

*NOTE.—In no case should "a" be less than ·10D, "b" less than ·15D, or "c" less than the maximum thickness of the rudder. The thickness is to be measured at the ·7R line above the shaft centre line.

TWIN SCREW SHIPS

104 The propeller tip-hull clearance should not be less than:—

3 blades: $1{\cdot}2k_2D$ but not less than ·2D

4 blades: k_2D but not less than ·2D

5 blades: $·85k_2D$ but not less than ·16D

6 blades: $·75k_2D$ but not less than ·16D

The clearance between the propeller and the shaft brackets or bossing should not be less than:—

3 blades: $1{\cdot}2k_2D$ but not less than ·25D

4 blades: k_2D but not less than ·25D

5 blades: $·85k_2D$ but not less than ·20D

6 blades: $·75k_2D$ but not less than ·20D

where

$$k_2 = \left(·1 + \frac{L}{10000}\right)\left(\frac{11{\cdot}2\ SHP}{L^2} + {\cdot}3\right)$$

$$\left(k_2 = \left(0{,}1 + \frac{L}{3050}\right)\left(\frac{1{,}025\ SHP}{L^2} + 0{,}3\right) \text{ metric}\right)$$

NOTE.—SHP = total shaft horse power installed.

16th June, 1966

R (H)—PROVISIONAL RULES FOR REPAIRS BY WELDING TO STEEL CASTINGS FOR CRANKSHAFTS

Section 1

General

101 Welded repairs are only to be undertaken when they are considered to be necessary and are approved by the Surveyor. Consideration must be given first to the blending of grooves formed by the removal of shallow defects, or to the machining of a surface where there is excess metal on the Rule dimension.

Generally, approval for repairs by welding will only be given to rectify areas where random and accidental defects arise. Approval will not be given for (1) the rectification of repetitive defects caused by improper foundry technique or practice; (2) the building up by welding of surfaces or large shallow depressions.

Position and Dimensions of Weld Repairs

102 Provided Surveyors are satisfied that repairs by welding are justified, they may authorise repairs to the surfaces of webs, within the following limits:—

(a) The specified maximum tensile strength of the steel is not in excess of 41 tons per square inch (65 kg. per mm.^{2}).

(b) In general, the volume of the largest groove which is to be welded is not to exceed $\frac{t}{2}$ in.^{3} (3,2 t cm.^{3}) where t is the web axial thickness, in inches or cm. The total volume of all grooves which are to be welded is not to exceed 1·5 t in.^{3} (9,6 t cm.^{3}) per web.

(c) The welds do not extend within the cross-hatched zones marked on Figs. 1(a) and 1(b) for fully-built and semi-built throws, respectively.

(d) Larger repairs on balance weights may be permitted at the discretion of the Surveyor provided such repairs are wholly contained within the balance weight and do not affect the strength of the web.

103 Weld repairs may also be authorised in the surface of the bore for the journal (or pin) within the following limits:—

(a) In general, the welds are to be not less than 5 inches (125 mm.) apart.

(b) The welds are not located within circumferential bands of $\frac{t}{5}$ from the edges of the bores, nor at any position within the inner 120° arc of the bores, as cross-hatched on Figs. 1 (a) and 1 (b).

(c) The volume of the largest weld is not more than about $\frac{t}{6}$ in.^{3} (1,1 t cm.^{3}) where t is the web axial thickness at the bore, in inches or cm., and not more than three welds are to be made in any one bore surface.

104 At the discretion of the Surveyor, the size of a groove may be increased somewhat beyond the limiting sizes given in 102 (b) or 103 (c) if the removal of further metal will facilitate welding.

Repair Procedure

105 All castings are to be given a preliminary refining heat treatment prior to the commencement of weld repairs.

Only experienced welders are to make the repairs and, at any time, the Surveyors may require a welder to demonstrate his ability to make a sound weld.

106 After all defective material has been removed from a region, and this has been proved in the presence of the Surveyor by magnetic particle inspection or other suitable method, the depression may be suitably shaped to allow good access for welding.

107 Before welding, the material is to be preheated to a temperature of not less than 200° C. Where possible preheating should be carried out in a furnace. The preheat temperature is to be maintained until welding is completed and preferably until the casting is charged to the furnace for post-weld heat treatment.

108 Welds are to be made by the electric arc process in the downhand (flat) position using low hydrogen electrodes which will produce a deposited metal in no way inferior in properties to the parent metal.

109 On completion of the repairs the casting is to be given a suitable heat treatment, which is to consist of either full annealing or normalising and tempering. Where small isolated defects are revealed after completion of full heat treatment as above, welding repairs followed by a stress

relieving treatment within the range 630/660° C. may be permitted.

110 Welds are to be dressed smooth by grinding and proved by magnetic particle inspection. The surfaces of the welds and adjacent parent steel are to be free from harmful defect.

Documentation

111 The foundry is to provide Surveyors with a statement and/or sketch detailing the extent and location of the welded repairs made to each casting together with details of the heat treatment carried out at all stages.

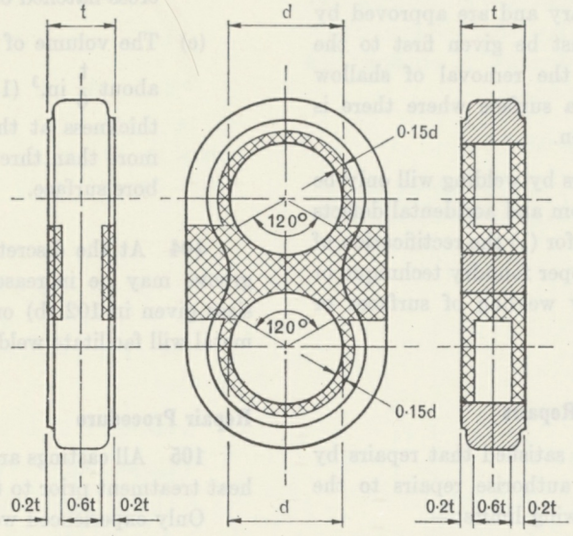


FIG. 1 (a)

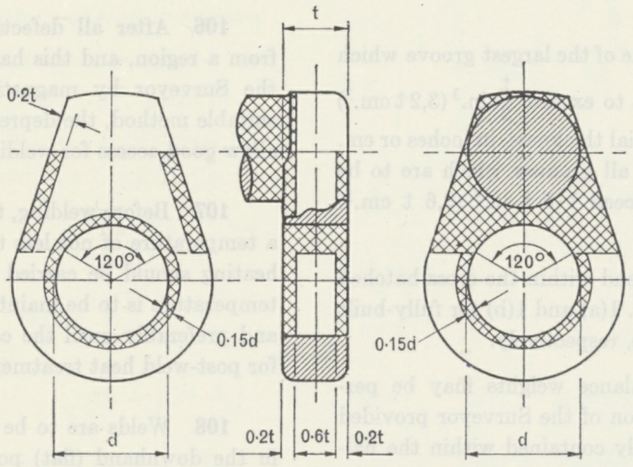


FIG. 1 (b)

16th June, 1966

By Order of the Committee,
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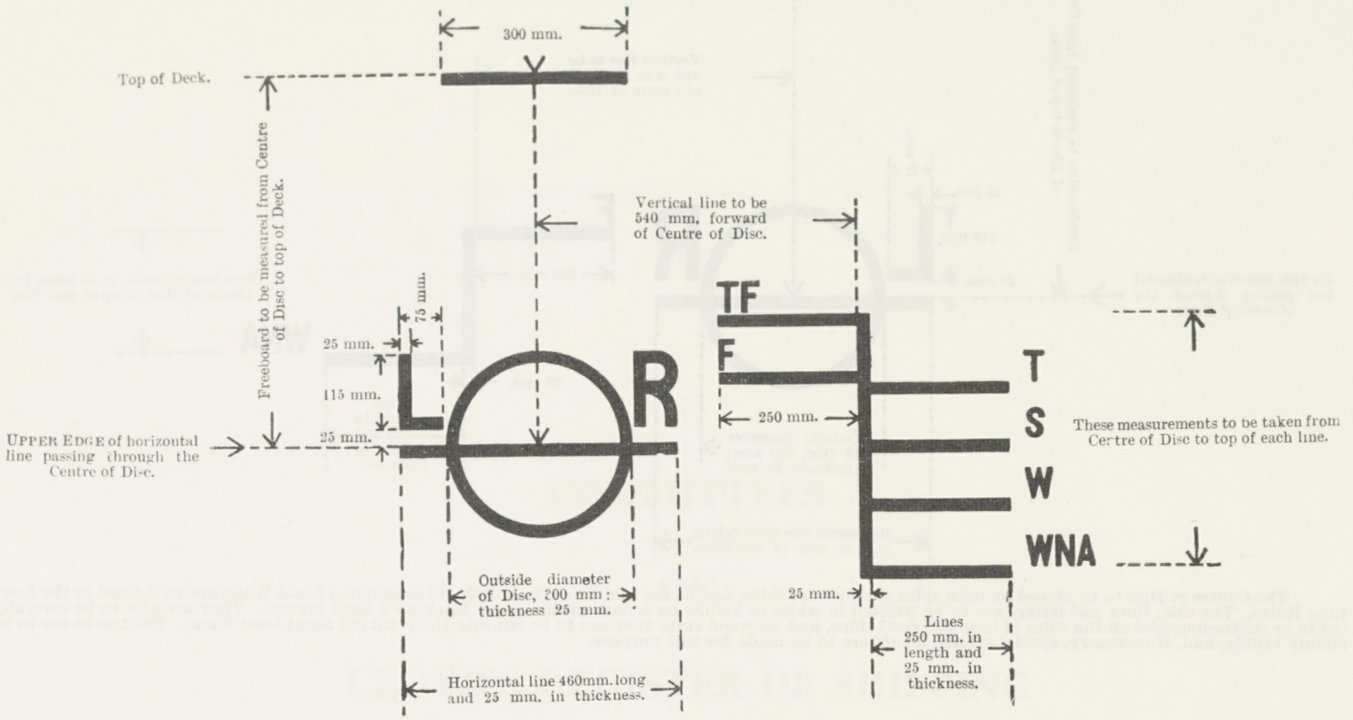

The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline as defined in the Load Line Rules. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least 3 mm. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose. Ships over 100 metres 50 in length are not required to be marked with the W.N.A. line provided they are not tankers or ships of special type having similarly reduced freeboards.

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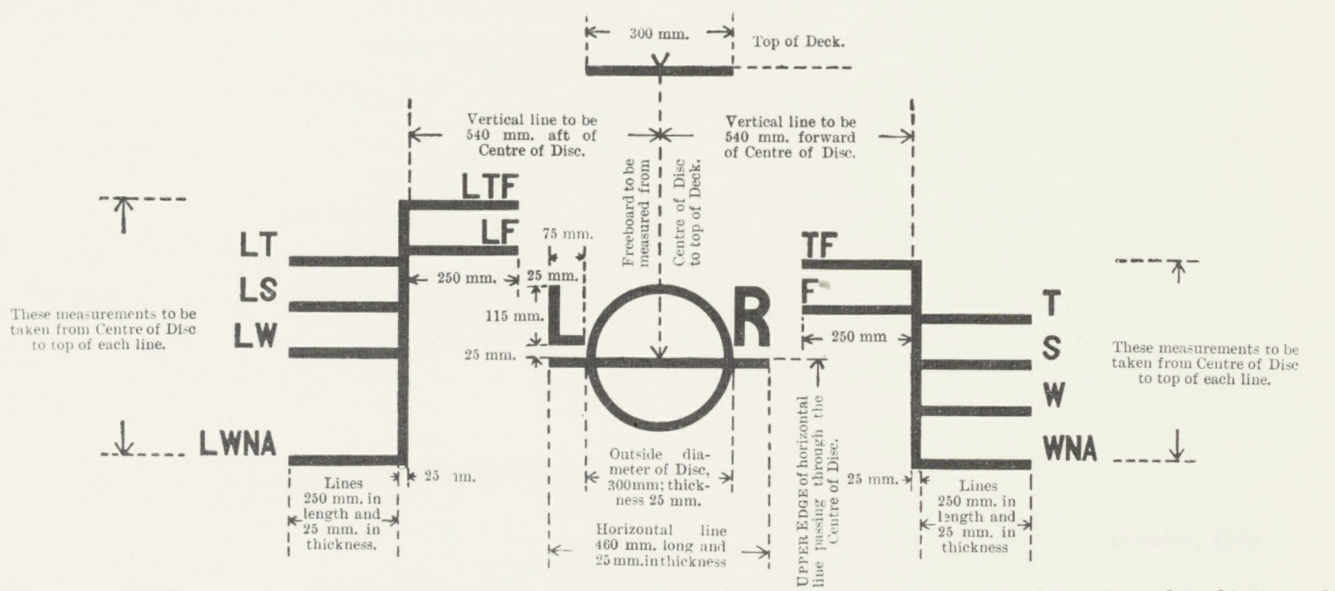

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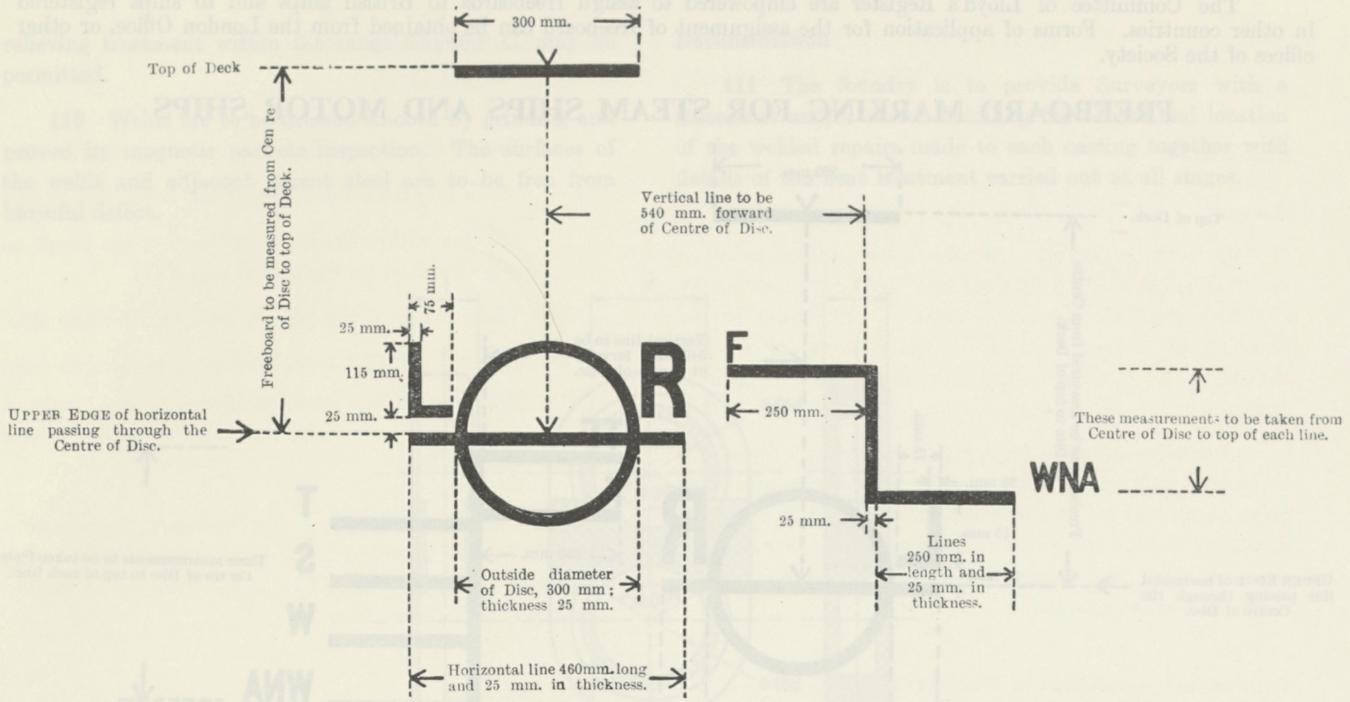

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October, 1966

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Office: Kilbacksgatan 31, Uddevalla
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Office: Safe Deposit Chambers, 3rd Floor, McLeod Road, P.O. Box 4922, Karachi
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Sub-Office at **NAGOYA**

Office: c/o Ishikawajima-Harima Heavy Industries Co., Ltd., Nagoya Shipyard, P.O. Box No. 33, 13, Showa-cho, Minato-ku, Nagoya

Telephone No. (611) 3111 Ext. 429
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Office: (Naka P.O. Box 92), c/o Mitsubishi Shipbuilding and Engineering Co., Ltd., Hiroshima Works, 1588, Eba-cho, Hiroshima

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RANGOON

Office: c/o Golden Bird Agencies, Ltd., 420, Merchant Street, P.O. Box 1298, Rangoon

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